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BUILDING PALOMAR'S 200-INCH

Great Lunar Eclipse

Which Stars Will Explode?

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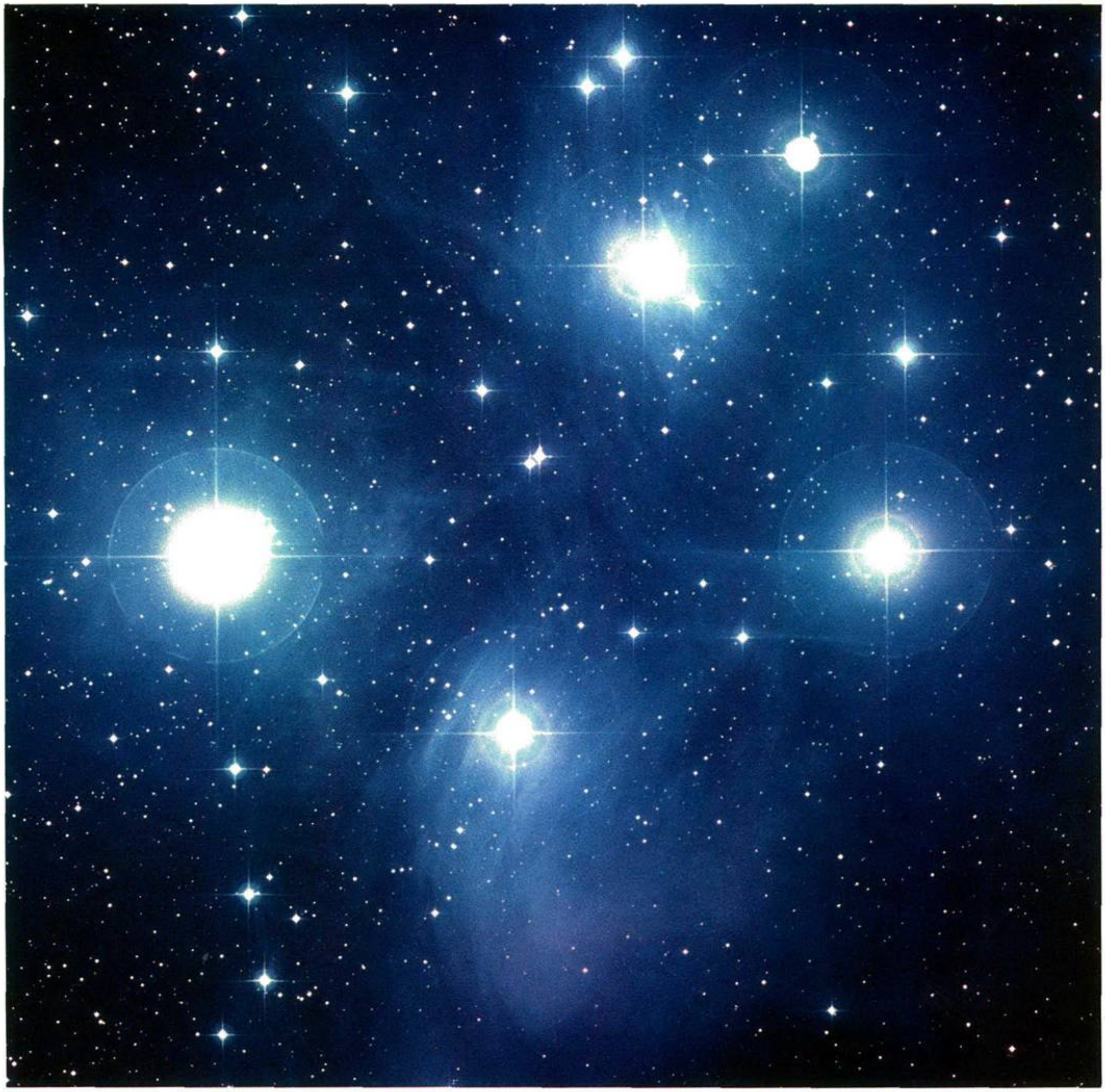

The Pleiades: Winter Sky Wonder

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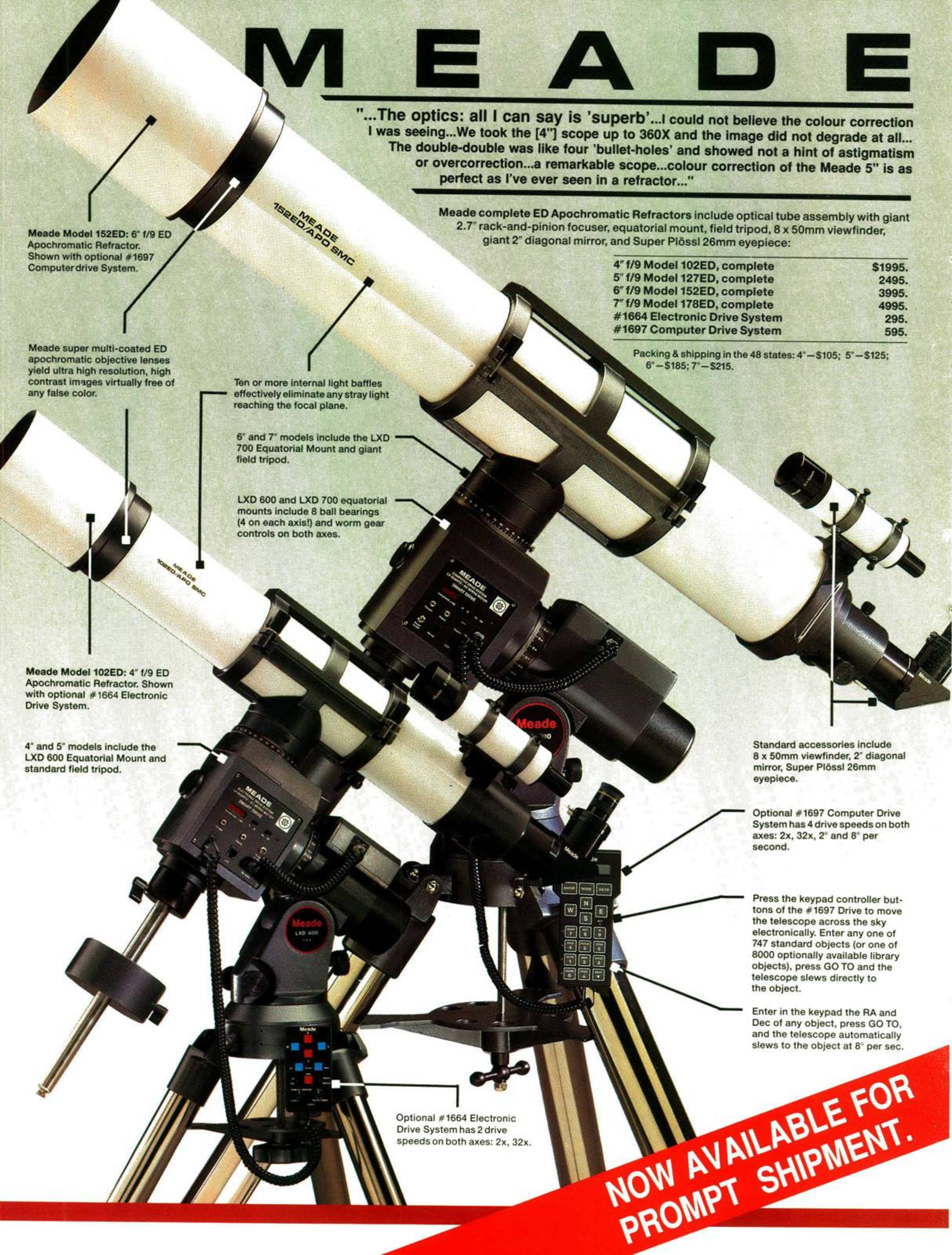
MEADE

"...The optics: all I can say is 'superb'...I could not believe the colour correction I was seeing...We took the [4"] scope up to 360X and the image did not degrade at all... The double-double was like four 'bullet-holes' and showed not a hint of astigmatism or overcorrection...a remarkable scope...colour correction of the Meade 5" is as perfect as I've ever seen in a refractor..."

Meade complete ED Apochromatic Refractors include optical tube assembly with giant 2.7" rack-and-pinion focuser, equatorial mount, field tripod, 8 x 50mm viewfinder, giant 2" diagonal mirror, and Super Plössl 26mm eyepiece:

4" f/9 Model 102ED, complete	$1995.
5" f/9 Model 127ED, complete	2495.
6" f/9 Model 152ED, complete	3995.
7" f/9 Model 178ED, complete	4995.
#1664 Electronic Drive System	295.
#1697 Computer Drive System	595.

Packing & shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



Meade Model 152ED: 6" f/9 ED Apochromatic Refractor. Shown with optional #1697 Computer drive System.

Meade super multi-coated ED apochromatic objective lenses yield ultra high resolution, high contrast images virtually free of any false color.

Ten or more internal light baffles effectively eliminate any stray light reaching the focal plane.

6" and 7" models include the LXD 700 Equatorial Mount and giant field tripod.

LXD 600 and LXD 700 equatorial mounts include 8 ball bearings (4 on each axis!) and worm gear controls on both axes.

Meade Model 102ED: 4" f/9 ED Apochromatic Refractor. Shown with optional #1664 Electronic Drive System.

4" and 5" models include the LXD 600 Equatorial Mount and standard field tripod.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional #1697 Computer Drive System has 4 drive speeds on both axes: 2x, 32x, 2° and 8° per second.

Press the keypad controller buttons of the #1697 Drive to move the telescope across the sky electronically. Enter any one of 747 standard objects (or one of 8000 optionally available library objects), press GO TO and the telescope slews directly to the object.

Enter in the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8° per sec.

Optional #1664 Electronic Drive System has 2 drive speeds on both axes: 2x, 32x.

OBSERVER REPORTS: *ED* APOCHROMATIC REFRACTORS

Never in the 20-year history of Meade Instruments has a new telescope series been so thoroughly tested—and received such acclaim—by some of the world's most demanding and discriminating astronomers. A sampling of the reports we have received on Meade ED Apochromats:

"As an apochromat **and** *Schmidt-Cassegrain enthusiast of 22 years standing, I have been more than a bit anxious to get my hands on the new Meade APO's and LX200 SCT's. I think it is paramount that a "mainstream" company has gotten involved in the development of apochromatic refractors, so the average person does not have to pay a fortune and wait almost a year to get a quality, high-performance refractor. With some friends, I recently put the Meade 4" 102ED and 10" LX200* [See the Meade LX200 ad of this issue] *through extensive testing. The 4" was virtually perfect. The mount was very solid and the computer drive made finding objects in light-polluted North York very easy. The fast electric slew feature was much appreciated because it eliminated the need ever to loosen the RA and Dec locks. Set-up and orientation of the scope were easy as well. The optics: all I can say is "superb." We looked at Saturn, Epsilon Lyrae, M13, and other Messier objects, and all were excellent. I could not believe the colour correction I was seeing: I detected no on-axis colour whatever. We took the scope up to 360X and the image did not degrade at all. Saturn was very detailed and the contrast of the equatorial band on the planet and the variation in the planetary colours was amazing for a 4" refractor. The double-double was like four "bullet holes" and showed not a hint of the astigmatism or overcorrection I have seen in so many other APO's claiming to be "state-of-the-art." The Meade 102ED is a remarkable scope. Any scope that can support almost 100X per inch is a first rate instrument—I have seen too many other APO's fall apart at 50X and even 30X per inch."*—**Richard Anderson, Mississauga, Ontario, Canada**

"Further to my letter regarding your 4" APO, I thought you might like to hear the results of tests on your 5" APO at the recent Canadian Starfest convention. Through the 5" Saturn was terrific. Aside from the usual things such as the Cassini division, I could see the olivine cap on top of the ball, as well as subtle detail in the main equatorial belt. What really struck me as amazing was the true-to-life colour rendition the APO provided. ***The colour correction of the Meade 5" is as perfect as I've ever seen in a refractor.*** *When I compared the Meade APO to a few* [competing brand of] *refractors, I was seriously wondering why anyone would pay the prices they charge—on all objects the Meade was as good or better. The diffraction disks of stars were more accurately rendered in the Meade than in the* [competing brand of] *6" APO at the site. I can wholeheartedly recommend the Meade 5" APO. In terms of comparison to other brands on the market, the Meade is superior."*—**Richard Anderson, Mississauga, Ontario, Canada**

"I've been an amateur astronomer since 1959 and have observed through all manner of telescopes large and small, up to 40" aperture. I am writing to tell you that images through the Meade 6" ED/APO are absolutely stunning even by professional standards. Image contrast and definition are amazing. The quality and workmanship are flawless. Having joined the A.L.P.O. in 1965, I can only speculate on how much additional and useful observational work could have been accomplished, had quality apochromatic refractors such as this been available those many years. The image quality even to the edge of the field is outstanding, while the color correction and contrast are simply better than any telescope I've ever used."—**Orville H. Brettman, Past President, The Astronomical League, Huntley, IL**

"In this country where apochromatic refractors are used by almost half of all serious amateurs, the introduction of Meade American-made ED/APO refractors was frankly met with some skepticism. This skepticism has dissolved rapidly, however, as word has spread about these very fine instruments. My personal tests with the Meade 5" ED have proven that this lens is clearly the equal of the finest Japanese ED lenses. Images through the Meade 5" ED are of high contrast and I could see no false color even at high power. Diffraction rings are virtually perfect. Using the computer drive, the telescope centered objects automatically and greatly increased my observing efficiency. Thank you for giving Japanese amateurs a chance at reasonable cost to use high-performance, large-aperture ED refractors."

—**Tadashi Sudoh, Tokyo, Japan**

"Last night I used the new Meade 6" and 7" ED apochromatic refractors. These are, without a doubt, among the finest telescopes I've ever used. Period. The LXD 700 equatorial mount is truly a remarkable telescope mount. The computer control is no less than startling. After spending 3 minutes polar aligning the mount, I then entered the command to find Saturn. The motors of the huge 7-incher slewed directly to the planet and placed it exactly in the center of the field of the 4.7mm eyepiece. And the views: I have never seen such razor-sharp images of Saturn before. Both scopes gave exceptional images. Stars are like tiny pinpoints. I could go on and on, but suffice it to say, these telescopes are really astounding."—**Darrell Green, Burbank, CA**

"I just wanted you to know how thrilled I am with my new 4" 102ED refractor. My standards for precision optics are exceedingly high; I am an eye surgeon and routinely use an $80,000 state-of-the-art microscope to perform cataract surgery. I'm happy to say that every aspect of the scope lives up to my standards and expectations. The mount is extremely rigid with excellent vibration dampening characteristics. The #1697 computer drive performs flawlessly. Lastly, and most importantly, the optics are superb. Planetary and lunar contrast and detail are simply breathtaking. My sincere thanks for the obvious thought and dedication that your company put into this magnificent precision instrument."

—**Barry S. Seibel, M.D., Los Angeles, CA**

"I had my first look through the Meade 6" APO at the 1992 Astrofest Star Party. While the lines were long in anticipation, I finally feasted my eyes on Saturn and was literally knocked back by what I saw. Not only was Saturn huge in the 240X field, but almost three-dimensional as well. As I studied the image, I remembered the old saying "Good things are worth waiting for," and this telescope is worth every minute."

—**Vic Winter, Kansas City, MO**

"At a recent star party many apochromatic refractors were set up, including a 6" Meade ED/APO. All during the evening I walked back and forth among these telescopes, carefully comparing relative optical performance. After looking through several 6" [competing brand] *3-element APO's (both cemented and air-spaced designs), I noticed in all of these scopes that Saturn's minor ring divisions, Cassini division, and the ball of the planet were not of the same contrast brightness, but seemed to vary inconsistently. Some areas of the planet seemed "underexposed," while other areas with potential detail appeared subdued. I repeatedly went back to a 3-element 6" f/12* [competing brand] *planetary APO, but found that all of the 3-element APO's had the contrast problem. Amazingly, the Meade 6" f/9 ED air-spaced doublet APO produced a brighter image with increased sharpness, allowing features to be seen more clearly than through competitive triplets. "Brighter, clearer, sharper" is the way I would describe the Meade APO when compared directly to lenses of other designs."*—**Robert Petti, Lyndhurst, OH**

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☐ For further information on Meade ED Apochromatic or Schmidt-Cassegrain telescopes, visit one of the hundreds of Meade dealer showroom locations throughout the USA; or contact one of the authorized mail-order dealers at left. Or call Meade Instruments toll-free at 1-800-854-7485 (in California 714-556-2291).

☐ *All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

☐ The all-new **1992 Meade General Catalog—$3.00** postpaid—is available from any authorized Meade dealer or directly from Meade Instruments.

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ON THE COVER: Wisps of nebulosity fill the space between the bright stars of the Pleiades (M45). A highlight of the constellation Taurus the Bull, this star cluster is but one of the splendid sights you can observe in the winter sky. (See page 80.) ©Anglo-Australian Telescope Board.

A BLOOD-RED MOON greeted observers during the May 1975 lunar eclipse. In contrast, this month's totally eclipsed Moon should appear dark gray. For details on viewing the December 9/10 eclipse, see page 74.

Ernie Piini

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The Audit Bureau

Behind the Scenes

PUSHING INTO THE UNKNOWN

Astronomy has always been about pushing back frontiers. In antiquity, the frontier lay only a few thousand miles from Earth. The invention of the telescope broke these bounds and gave astronomers a tool to push back the frontier in earnest, and advances moved in step as telescope apertures increased.

Some 64 years ago, American astronomer George Ellery Hale began to put a dream into action. Three times before, Hale had been the prime mover in building the world's largest telescope — first the 40-inch refractor at Yerkes Observatory (1897), then the 60-inch reflector at Mount Wilson (1908), and the 100-inch reflector, also on Mount Wilson (1917).

This last instrument sketched in the shape of the modern cosmos. But paradoxically it mainly showed the need for a still larger telescope. Undaunted by poor health, Hale set out a fourth time in 1928 to help astronomers reach the edge of the universe. The result was the famed 200-inch reflector sited on Palomar Mountain.

In the same way as Boulder Dam, the 200-inch was a Big Project. The story of building it (see page 28) carries us back to a day when engineering breakthroughs meant finding ways to make 500 tons of glass and steel move with micrometer precision in whispery silence. Hale knew that building this instrument would give the country an edge in science that none other possessed.

Remarkably, the 200-inch has kept that edge even today. CCDs and computers have all but replaced photographic plates and mechanical measuring engines, but the telescope's prime function — collecting 210 square feet of celestial light for study — remains unchanged. Thanks to periodic upgrades, the 200-inch is one of the most productive telescopes on Earth, with astronomers night after night seeking knowledge at the limits of the universe.

Where's the edge of your universe? Even if you observe with the naked eye it may lie farther than you think. After all, the soft light coming from the Andromeda Galaxy (see page 80) has traveled more than 2 million light-years before it reaches your retina.

But a backyard telescope takes you much farther still, with greater clarity and detail. And is there a telescope owner alive who hasn't at some time reveled in the quiet knowledge that his or her scope and Palomar's — though greatly different in size and design — nonetheless share many of the same "magic carpet" abilities?

There's excitement in owning a telescope because it links you to every astronomer, past or present. It doesn't matter that neither you nor I will likely use the 200-inch or its new, vastly larger descendants. What does matter is that our backyard scopes give us means to probe the beauty of the heavens and the limits of our own understanding. As Hale once said, every clear night starlight is falling ceaselessly upon the Earth. All we need to do is take a telescope out and catch some of it.

Sincerely,

Robert Burnham

Robert Burnham
Editor

ASTRONOMY

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Letters

Lookback Time

I would like to respond to Lee Park's emotional ordeal in "Lookback Time," the September 1992 Viewpoint, with my own experience. In my opinion, we return to telescopes and star charts because we *used* to love the stars. We're trying to relive those carefree, relaxed nights we experienced when we started out in the hobby.

All too often, however, as beginners we move too quickly from testing the waters to jumping straight in. In my own case, I immediately built the 10-inch telescope in Richard Berry's book (a very fine instrument), tackled the Messier and Herschel lists, let asteroids and planetary nebulae cut notches in my observing cap, and spent the remainder of my free time in the local club. Small wonder that hints of depression, loneliness, and even some resentment began to set in. Lee pointed out the syndrome of observer's guilt — actually anticipating those cloudy nights. Wow, I wasn't the only one who felt this way. How many other amateur astronomers have been through this? — *Dennis Culver, Von Braun Astronomical Society, Huntsville, Alabama*

Seeing to the Edge

To answer Larry Mitchell's letter in the September 1992 ASTRONOMY — Yes, there are others out there who enjoy tracking down distant quasars. The quasar Molonglo 3 has long been a favorite for observers seeking to expand their horizons. However, a news item in the July 1992 ASTRONOMY announced the discovery of an even better target. The quasar called HS 1946+7658 is much more distant and is also brighter! It has a redshift of $z = 3.0$ and an apparent visual magnitude of 15.8. This very luminous quasar is almost 90 percent to the edge of the observable universe.

We were both able to sight this object in an 8-inch Schmidt-Cassegrain at high power. We used a finder chart from the January 1992 *Astronomy and Astrophysics* and a portion of a Palomar Sky Survey photograph to pinpoint its exact location. — *Jerry Spevak and Kwai Wong, Richmond Hill, Ontario, Canada.*

Mystery Sungrazer Identified?

In the August Letters Joseph Marcus suggests that an object seen near the Sun on December 21, 1882, might have been a sungrazing comet. Might I suggest that the object was more likely the planet Venus?

After inferior conjunction on December 6, 1882 (when it transited the Sun),

[continued on page 12]

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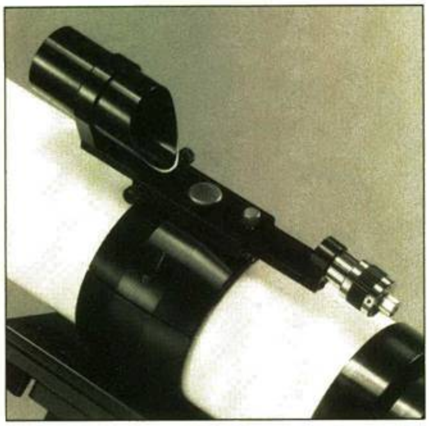

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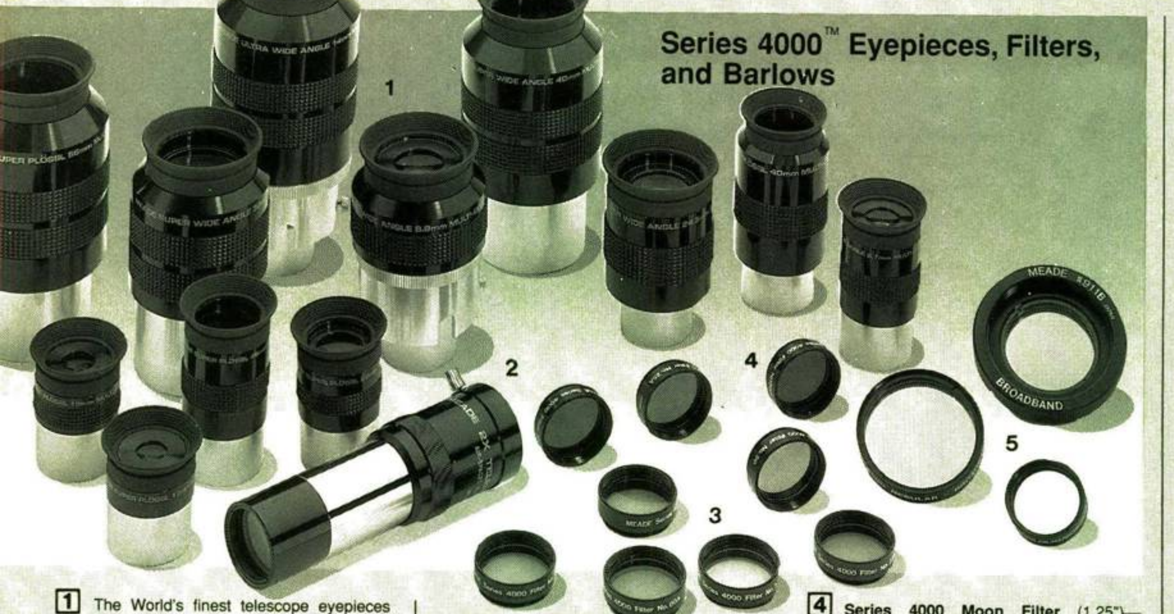

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Rack-and-Pinion Focusers (2")

#680--The most popular 2" focuser ever manufactured. Thousands in use. Spring-loaded gearbox; 3" travel. Includes 1.25" and 2" eyepiece-holders. **89.95** (3.48)

#682—Low-profile 2" focuser; body height only 1.75". Spring-loaded gearbox. Travel: 2.5". Includes 1.25" adapter. **99.95** (3.48)

Viewfinders: 30mm, 50mm, 60mm

#637: 6 x 30mm--Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece, 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$39.95** (2.79)

#545: 8 x 50mm- *(lower photo)* Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **59.95** (3.48)

#544: 8 x 50mm-- Same as #545, but in Meade blue. **59.95** (3.48)

#957: 9 x 60mm--*(top photo)* Collects 44% more light than 50mm; superior for faint objects; bracket below. **89.95** (3.78)

Bracket for 8 x 50mm: Fits Meade and Celestron SCT's, and other tubes from 7" to 20" diameter. **17.95** (1.79)

Bracket for 9 x 60mm: Fits tubes from 7" to 20" diameter. Removable dovetail included. **22.95** (1.79)

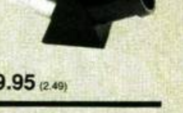
Multi-Coated Giant Binoculars

Superb, fully multi-coated 11 x 80mm and 20 x 80mm Giant Binoculars, ideal for wide-field deep-space observing. **Rubber-coated bodies for rugged field use!** BAK-4 prisms yield bright, sharp, high-contrast images. Hard carry case, tripod adapter included.

11x80: $359.95 (4.87)

20x80: $379.95 (4.87)

45° Erect-Image Diagonal Prisms



Originally developed by Meade Instruments, these convenient diagonals erect the astronomical image, for terrestrial use of astronomical telescopes. Fully coated.

#927: for .965" focusers.
#928: for 1.25" focusers.
#931 Hybrid: accepts 1.25" eyepieces, fits .965" focusers.

Specify model desired. each: **$49.95** (2.49)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25" **$119.95** (2.79)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$99.95** (2.79)

MA 12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$89.95** (2.79)

MA 12mm-Same as above, but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$69.95** (2.79)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$89.95** (2.79)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": $24.95 (2.49) **1.25": $29.95** (2.49)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.49)

Tele-Extenders

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$26.95** (2.49)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece. **$36.95** (2.49)

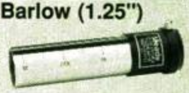
T-Adapters for SCT's

For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera. **$26.95** (2.49)

2X Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (2.49)

2x-3x Variable Barlow (1.25")



#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated: 1.25" **$59.95** (2.49)

Orthoscopic Eyepieces (1.25")

Fine 4-element oculars that yield excellent image quality with any telescope. Computer-optimized design provides wide, flat fields, highly corrected for spherical and chromatic aberrations. Parfocal, multi-coated, 1.25" barrels. Threaded for filters. **Focal Lengths: OR 4, 6, 9, 12.5, 25mm.**

each **$47.95** (2.49)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, the 3-element MA gives sharp, faithful, well-corrected images of the Moon, planets, and deep-space. Multi-coated; threaded for filters. 1.25". **Focal Lengths: MA 9, 12, 25, 40mm.**

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■ Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.

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■ Meade accessories may be ordered from any Meade Advanced Products dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA
Orders: 800-843-4780; Info: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
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LUMICON, Livermore, CA.
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Orders: 800-235-3344; Info/CA:805-522-6701

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Model 395 — 90mm f/11 Equatorial Refractor: Includes multi-coated, achromatic, air-spaced objective lens; 1¼″ rack and pinion focuser; 6 x 30mm viewfinder; diagonal mirror; MA 25mm eyepiece; equatorial mount with dual-axis slow-motion control cables and setting circles; deluxe all-aluminum field tripod. **$599**

Meade 60mm refractors are priced from **$149 to $399.** Call or visit your Meade dealer for details. *Shown:* **Model 285 — 60mm f/15 Equatorial Refractor,** with multi-coated, achromatic, air-spaced objective lens; rack and pinion focuser; 1¼″ diagonal mirror; 6 x 30mm viewfinder; MA 9mm and MA 25mm eyepieces; equatorial mount with dual-axis slow-motion control cables and setting circles; full-length hardwood tripod.

Model 390 — 90mm f/11 Altazimuth Refractor: Includes multi-coated, achromatic, air-spaced objective lens; 1¼″ rack-and-pinion focuser; 6 x 30mm viewfinder; diagonal mirror; MA 25mm eyepiece; altazimuth mount with slow-motion control cables on both axes; deluxe all-aluminum field tripod. **$499**

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OBSERVER REPORTS: *LX200* SCHMIDT-CASSEGRAINS

"...After hours and hours of using this instrument, it is clear the quantum leaps that Meade has made in telescope technology...Planetary contrast and detail were simply unlike any 8" SC telescope that I had ever tested before...The more people looked, the faster word spread that something truly extraordinary was going on..."

"Last weekend I arrived at our club's dark sky site and set up next to a brand-new 8" LX200 owned by Mark, one of our club members. This was going to be a fun evening. Mark punched in a request for M57, the Ring Nebula. Less than 10 seconds later there it was, exactly in the center of the eyepiece! Very sharp image too. Next we tried a long slew, off to M31, the Andromeda Galaxy. Took about 15 seconds and there was the core of M31, again centered in the eyepiece. We punched in a request for Saturn. The scope buzzed over and centered the beautiful ringed planet (this could make a finderscope obsolete!). We ran the power up on Saturn. The LX200 gave a splendid view. Sharp image, lots of contrast. Refractor-like. The optics on this scope were outstanding, and the combination of ease of use and superb optics was impressive. This scope had better contrast and much sharper optics than I've seen on other SC's. One of the club members went inside to call his wife and let her know he was buying one. Congratulations! This is a very desirable scope you've created."—**Bob Beckley, Bedford, MA**

"I have made my best purchase of a lifetime. I saved for two years to have a superior telescope of my dreams and you have made them come true with the 10" LX200. The optical quality one must see to believe. I was actually able to see hints of dust lanes in M31 and spiral structure in M82; my greatest thrills were a confirmed sighting of Pluto and the resolution of M13 into individual stars. I have been in amateur astronomy for 23 years and I have never used such an incredible telescope."—**Michael D. Cloutier, Fair Haven, MI**

"While vacationing over the past week, I've had a chance to put the 8" LX200 through its paces. You've gone beyond the future and into sci-fi with this telescope. I want you to know that the LX200 has exceeded all my expectations, even better than my fondest dreams for a telescope of the future. Congratulations!"—**Roger Ressmeyer, Sag Harbor, NY**

"Because Schmidt-Cassegrain quality has been a personal crusade on my part, I was champing at the bit to test the new Meade 10" LX200. I have always believed that building an excellent Schmidt was within the realm of possibility, and the new LX200 is a real winner. The optics are so good I am now having trouble understanding how you can produce them to the level you have and sell them so inexpensively. I have been "educated" by "optical experts" who said it can't be done. I now have proof that it is possible. Because I know a Schmidt's optics are complex, I always test them with a Ronchi eyepiece as well as real objects. The Ronchi tells if the surface curves are ***accurate*** *and if the surfaces are* ***smooth.*** *Lack of smoothness will kill planetary detail by diffusing light into a hazy cloud around the planet. When I put the Ronchi on the Meade LX200 I couldn't believe what I saw! The bands produced by the Ronchi pattern indicated a surface as smooth as* ***any*** *refractor I have ever seen!! This level of smoothness is incredible in any reflective optical system. The Ronchi bands were also ruler-straight, indicating that the curves on the optics were right-on. No over- or undercorrection. Saturn was magnificent! The planet displayed more contrast and better colour rendition than any Schmidt I have ever owned—and I've owned 8 of them! The equatorial belt was markedly reddish-brown; the Cassini division was darker than I've ever seen it and I could easily see the Crepe ring thanks to the scope's high contrast. Views of deep-sky objects were excellent: M27, M57, and M13 all looked great despite light pollution at the site. The computer drive performed well. I quickly jumped from object to object and turned what was going to be a quick half-hour test into a very enjoyable* ***four-hour*** *observing session. There will be no trade-in of this instrument down the road, because you don't trade in perfection."*—**Richard Anderson, Mississauga, Ontario, Canada**

"At a star party in Austria last weekend I used an 8" LX200 for testing and observations. After hours and hours of using this instrument, it is clear the quantum leaps that Meade has made in telescope technology. Views of Saturn were startling! Planetary contrast and detail were simply unlike any 8" SC telescope that I had ever tested before! Stars were crisp and sharp. The more people looked, the faster word spread that something truly extraordinary was going on: Now people came with their testing tools and a Ronchi-grating confirmed the overwhelming impressions that everyone had during those observations. All lines were absolutely straight. Once the LX200's computer started to let the servomotors hum, the telescope attracted everyone on the observing grounds. I was scanning the heavens and soon people were standing in line to see NGC and Messier objects in rapid succession. Common exclamations were that here was a truly quality telescope that was a joy to use."—**Stefan Thiele, Wiesbaden, Germany**

"The key word to describe my 10" LX200 is versatile. The LX200 is as simple or as sophisticated as my needs dictate. For casual observing I can quickly and accurately move from object to object. The superb optics and smoothness of the mounting make centering objects a visually exciting endeavor, not a fight. When I'm ready to use the technical sophistication of the LX200, the keypad handbox makes finding objects a matter of pushing a couple of buttons. I find that the LX200 makes technology work with me. I also have to mention the excellent support I have received from Meade. Any time I have called with a technical question, I have talked with a "live" person who is not only eager to answer my question but truly concerned with whether or not I am enjoying my scope. I find Meade's approach to business to be truly refreshing."—**Steven L. Renshaw, Fresno, CA**

"I've owned 3 Schmidt-Cassegrains and a 12.5" Newtonian over the years, and recently at our club observatory, I used the most sophisticated commercially-available telescope I've ever seen, the Meade 10" LX200. I was impressed by the sharpness and contrast levels of the LX200. In light-polluted areas of New Jersey the use of a nebular filter is often required to enhance the contrast of deep-space objects, but when I saw the Crab Nebula (M1) clearly through the 10" LX200 ***without*** *a filter, I knew that the optics of the LX200 were obviously of the highest quality. As a result of this experience, I have ordered a Meade 10" LX200 for myself!"*—**John W. H. Simpson, Princeton, NJ**

"As an 8" LX200 owner, I am writing to tell you that I really love the instrument. In side-by-side testing against a friend's [competing brand of] *8" SCT, to say the least there was no comparison. My Meade LX200 was light-years ahead in optical quality and technical capabilities. The LX200 is clearly the best Schmidt-Cassegrain in the world. Period."*—**Jinder Virdee, St. Thomas, Ontario, Canada**

"I recently purchased the Meade 10" LX200 and have been enjoying the scope immensely. You have produced a very high quality product and it has lived up to all my expectations and beyond. The LX200 makes astrophotgraphy a pleasure. The telescope's Smart Drive did a great job of assisting me in the 20-minute photo of M22, enclosed; it took very little effort as the telescope did basically all the work. You can bet I will highly recommend the LX200 to any amateur astronomer looking for a superb telescope."—**Alfredo Garcia, Las Vegas, NV**

"Having just returned from two evenings of viewing on Mt. Pinos, I felt compelled to write you about my experience, as this was my first chance to really take my new 10" LX200 through its paces. What a wonderful combination of superb optics, rigid mounting, and accurate electronics!! I can't remember ever having spent a more enjoyable or productive evening observing! I emphasize 'observing' because that's what the LX200 allowed me to do. Having the telescope slew to my requested objects allowed me to enjoy viewing more objects than I ever thought possible. And speaking of viewing, what great optics! Amazing contrast, pinpoint star images. I have never seen as much detail in the cloud bands of Jupiter. I can't say enough about this scope. It was a breeze to set up (I was aligned, tracking, and observing in 5 minutes). The mounting is VERY solid. This telescope has an amazing array of features, outstanding optics and mounting. You've produced an outstanding product."—**Charles Kuhn, Culver City, CA**

Shouldn't you be using the most advanced Schmidt-Cassegrain ever manufactured? Meade 8" and 10" LX200's are available for prompt shipment. Call or write your authorized Meade dealer today for full details.

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10" LX200 Schmidt-Cassegrain	**2495.**
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Packing and shipping in the 48 states: 8"—$105; 10"—$145

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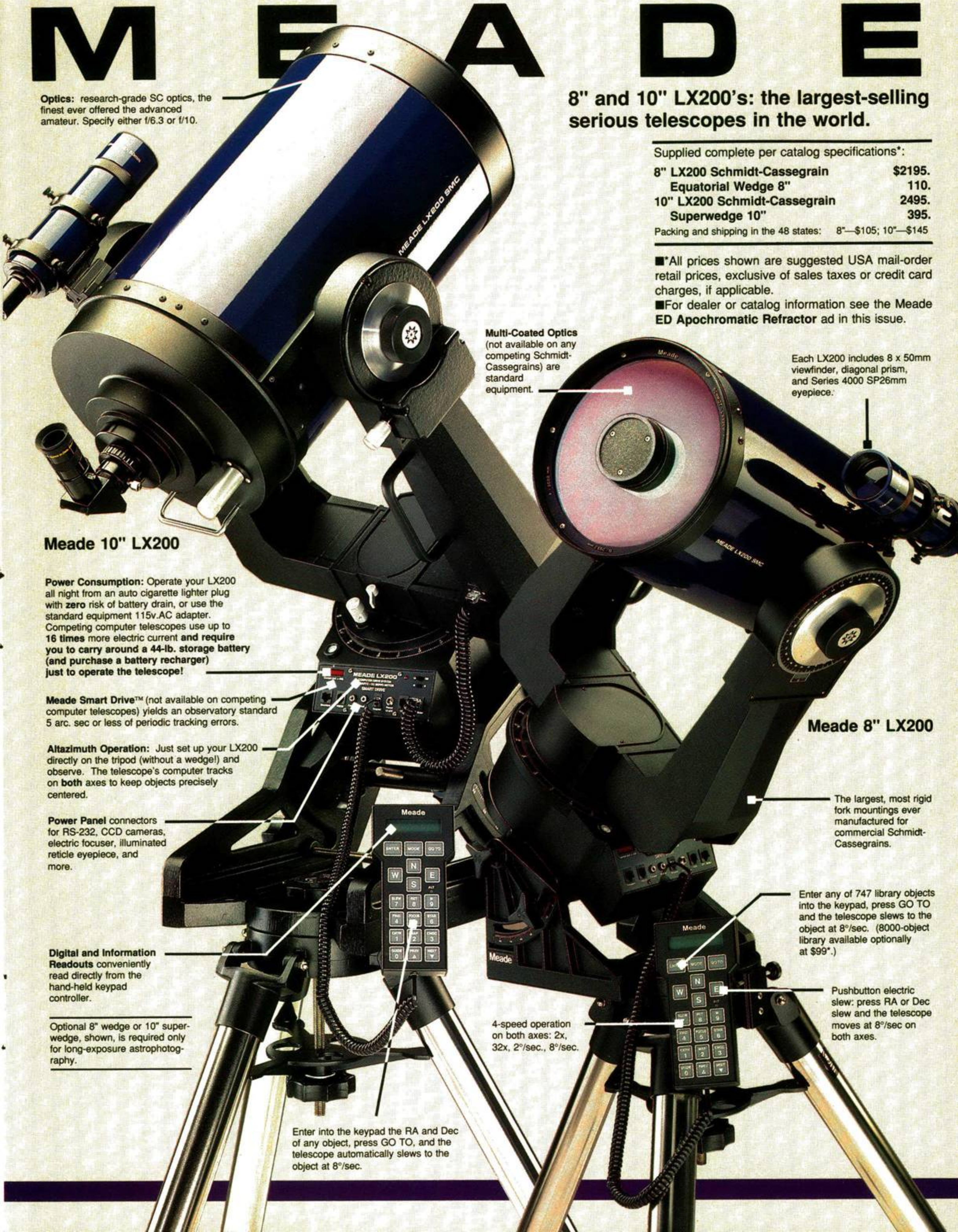
■For dealer or catalog information see the Meade **ED Apochromatic Refractor** ad in this issue.



Optics: research-grade SC optics, the finest ever offered the advanced amateur. Specify either f/6.3 or f/10.

Multi-Coated Optics (not available on any competing Schmidt-Cassegrains) are standard equipment.

Each LX200 includes 8 x 50mm viewfinder, diagonal prism, and Series 4000 SP26mm eyepiece.

Meade 10" LX200

Power Consumption: Operate your LX200 all night from an auto cigarette lighter plug with **zero** risk of battery drain, or use the standard equipment 115v.AC adapter. Competing computer telescopes use up to **16 times** more electric current **and require you to carry around a 44-lb. storage battery (and purchase a battery recharger) just to operate the telescope!**

Meade Smart Drive™ (not available on competing computer telescopes) yields an observatory standard 5 arc. sec or less of periodic tracking errors.

Altazimuth Operation: Just set up your LX200 directly on the tripod (without a wedge!) and observe. The telescope's computer tracks on **both** axes to keep objects precisely centered.

Power Panel connectors for RS-232, CCD cameras, electric focuser, illuminated reticle eyepiece, and more.

Digital and Information Readouts conveniently read directly from the hand-held keypad controller.

Optional 8" wedge or 10" superwedge, shown, is required only for long-exposure astrophotography.

Meade 8" LX200

The largest, most rigid fork mountings ever manufactured for commercial Schmidt-Cassegrains.

Enter any of 747 library objects into the keypad, press GO TO and the telescope slews to the object at 8°/sec. (8000-object library available optionally at $99*.)

Pushbutton electric slew: press RA or Dec slew and the telescope moves at 8°/sec on both axes.

4-speed operation on both axes: 2x, 32x, 2°/sec., 8°/sec.

Enter into the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8°/sec.

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Venus moved rapidly to the north and west of the Sun. By December 21 it would have been more than 20° from the Sun and nearly at its greatest brilliancy. Telescopically, it would have appeared as a thin crescent. This corresponds to the object described in the letter quoted by Mr. Marcus — a starlike object when seen with the naked eye but a crescent when seen through a telescope. At the time of day mentioned, Venus would have been above and to the right of the Sun, also roughly in agreement. — *Warren Morrison, Cavan, Ontario, Canada*

Are Asteroids Dead Comets?

In "Interplanetary Fugitives" (August 1992) Lucy-Ann McFadden and Clark R. Chapman point out that the best candidates for transition comets are asteroids that travel in highly elliptical orbits. While these objects have orbits that most resemble the orbits of short-period comets, readers should know that a number of asteroids have been observed with cometlike comae. They do not move in highly elliptical orbits, but reside in the main asteroid belt.

James Secosky and I hope to use the Hubble Space Telescope to study select asteroids for evidence of a cometary origin. We have been selected as semifinalists and are waiting for the final selection in phase two of the amateur competition. — *Harald Schenk, Sheboygan, Wisconsin*

A Constellation Convert

I just finished reading my second issue of ASTRONOMY. I have been actively interested in star gazing for one year and I found "Exploring the Summer Sky" by Deborah Byrd in the June 1992 issue to be very helpful. If I had had the article last year, I might not have taken all summer to figure out which stars were which in the Summer Triangle. Please continue to write articles for us beginning amateurs. — *Denise Taylor, Lexington, Kentucky*

A Happy Hopper

I thoroughly enjoyed reading the article "Hop Into Deep-Sky Observing" (September 1992) and I wish that ASTRONOMY would print more "how to" articles like this. I have used the star hopping method described to find all 110 Messier objects without using setting circles. I have a straight-through 5x24 finderscope and use it in conjunction with a field edition of the *Tirion Sky Atlas 2000.0*. When I use the finderscope I orient the Tirion atlas upside down, look through the finder, and star hop to my destination using a empty roll of masking tape for a template on the star atlas. — *Alan Pasicznyk, Doylestown, Pennsylvania*

The Cosmic X

The image of a probable black hole in the center of the Whirlpool Galaxy (September 1992 AstroNews) was fascinating. It struck me that the double dust rings could be produced if M51 contained two orbiting black holes with axes aimed in distinctly different directions. Could this be a viable explanation? — *S. Kolonourus, Chicago, Illinois*

— First, some astronomers are not convinced the object at the center of M51 is a black hole. It could be a region of active star formation — a starburst object. However, if there were two black holes at the M51's core we would expect to see two pairs of radio jets emanating from the core region. Astronomers observe only one pair.

Spaceship Tombaugh

The article "To the Edge: Missions to Pluto and Neptune" (May 1992) stated that the craft to visit these worlds have yet to be named.

Would it not be appropriate to name these two new spacecraft in a similar way to the Galileo and Cassini probes? The craft to visit Neptune could be named Adams-Le Verrier or Le Verrier-Adams, after the men whose calculations led to the discovery of Neptune.

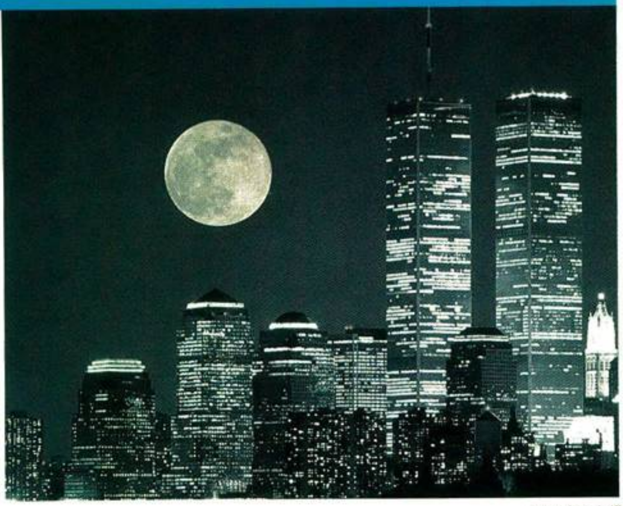
I don't think a hand would be raised in protest if the craft to go to Pluto were named after its discoverer, Clyde Tombaugh — the Tombaugh mission to Pluto. — *Paul Byrne, Dublin, Ireland*

Correction

The Flat Field Camera from Lichtenknecker Optics profiled in the August 1992 New Products department was stated incorrectly as being compatible with 6x7-format camera bodies. Due to the short back focus required by the FFC's fast f/ratio, a 6x9 or 6x7 Wista roll film adapter which clips into the International 4x5 roll film holder offered by Lichtenknecker Optics is the only means of obtaining medium format images. ☐

ASTRONOMY welcomes comments and additional information on articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

BLINDED BY DARK SKIES



Larry Landolfi

by Rod Pommier

I used to believe that the backyard astronomers who saw the most were the ones who lived under the darkest skies. I now know that the backyard astronomers who see the most are the ones who *look* the most. But I didn't learn that until I moved from dark skies in Oregon to the heavily light-polluted skies of Manhattan. Losing my dark skies taught me to see many things I previously had ignored.

When I learned that my career would take me from Portland, Oregon, to Manhattan for two years, I knew major changes involving my pursuits in amateur astronomy would be in store. In fact, I was sure that the move would ruin my hobby. In Oregon I was spoiled rotten. I had a safe, spacious yard from which I could observe as often as I wished. The light pollution in Portland was only moderate, and I could easily see many deep-sky objects from my backyard. Very dark skies were only 30 minutes away — and three hours away, at the summit of a 7,000-foot mountain in central Oregon, the skies were incredibly dark. The summer Milky Way there was bright and detailed. I could observe and take astrophotographs to my heart's content.

In Manhattan, things were going to be different. Light pollution fills the sky and I'd hardly recommend observing alone at night. Furthermore, because parking is nearly impossible, friends advised me to sell my car before moving: I would be stranded in the city. These conditions made me feel hopeless, but in the end I decided to bring my telescope anyway. When I arrived, my worst fears were confirmed. Manhattan skies glowed pink with light pollution and I could see only the brightest stars. I was convinced that astronomy wouldn't be possible.

After sulking for weeks, I bought some astronomy software, thinking I could at least do astronomy on a computer screen. I began to have fun predicting planetary conjunctions. I was thrilled when I saw them appear in the sky exactly as predicted. Using my camera and tripod, I photographed some conjunctions over the city skyline. This made me realize that a shot of the Moon setting over the Chrysler Building would be dramatic. No problem! My software gave the date and time when the Moon would have the proper altitude and azimuth. At the predicted time, I took beautiful photos of an orange Quarter Moon suspended just above the Chrysler Building's art deco spire. While this aspect of amateur astronomy differed from what I was used to, I was beginning to have fun with my hobby once more.

But I desperately wanted to use my scope again. I realized that I could use it safely by day if I tried solar observing, so I ordered a filter and began observing the Sun. This opened a whole new world. I loved to observe the Sun. Tracking and photographing sunspot groups became an important observing activity and I began amassing data on sunspot activity in a computer file.

It struck me that the software I used to predict planetary conjunctions also gave coordinates for the Sun and planets. With good polar alignment, I could use the Sun to find planets during the day. Sure enough, within minutes of my first attempt, I located a silvery crescent Venus. By observing it in daytime, I followed Venus through all of its phases. I also found in the daytime sky the ghostly disks of Jupiter and Saturn, as well as tiny crescent Mercury. I found that daytime views of Mercury, when it's high in the sky, were far superior to any twilight views when it's low on the horizon. This was exciting stuff!

I was determined to use my telescope at night but I needed a site where I could observe safely. The doorman of my apartment building let me observe from

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the roof. There I had an unobstructed view over the East River and a view only partially obstructed by skyscrapers to the west. I attempted to find bright deep-sky objects, but this was difficult. Many objects were invisible in the finderscope and barely visible in the main one. Finding objects required that I consult star atlases carefully, use setting circles proficiently, and master complex patterns of star-hopping.

However, before I knew it I was finding objects that I'd never found back in Oregon. True, the views of the objects were quite poor, but it was obvious that my navigational skills had improved. Now, when I can't find something, I know I'm looking at its exact location but I can't see it because of the light pollution. Before, when I couldn't find things under dark skies, I had ineptly lost my way.

I grew hungry for more objects. ASTRONOMY provided maps to locate bright asteroids, but I had never observed an asteroid. With my improved navigational skills, I rapidly found the right star fields. It was thrilling to check the same fields the next night and note my asteroid candidates indeed had changed position.

One night, I viewed Mizar and Alcor in the handle of the Big Dipper. Despite the light pollution, the view was good. It struck me that I could observe double stars with relatively little interference from light pollution. I owned an entire catalog of double stars but had never read it. Immediately, I began looking at doubles. At first I observed easy pairs, but soon I tried more difficult doubles. Once again, my skills grew. Before long I found myself waiting silently on my rooftop for those moments of excellent seeing when a very close double star would split apart for a few seconds into two stars. The thrill of splitting a close double after hours of patient observing was new to me and rewarding.

Well, if I could do double stars in Manhattan, then perhaps I could observe other types of stars as well. I also had a book about variable stars. After locating the first variable, I made periodic estimates of its magnitude, eventually plotting a curve of its magnitude versus date. I was astounded to see that my curves yielded all kinds of information about the star. I found that it is an eclipsing binary and that it has partial rather than total eclipses. I determined the orbital period and which of the two stars is larger. Here I had real data about real stars that I had collected myself. My graph gave me a link to this star system

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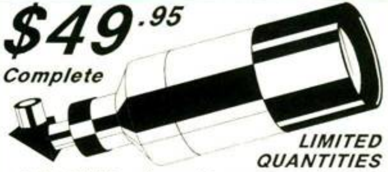

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that I hadn't realized was possible. Before, it was just a boring variable. Now it was a complex star system I understood and could visualize.

At this point I joined a local astronomy club. One autumn evening I ventured to a city park with my scope for one of their public observing sessions. This was my first experience with sidewalk astronomy. I was one of three club members there with a telescope, but there were several hundred New Yorkers dying for their first look through a telescope. People waited in line for hours to look through my scope at the Moon and Saturn and told me how excited they were to see craters on the Moon or the rings and satellites of Saturn. My heart warmed when the eyes of children lit up with astonishment as they looked at another world for the first time. Later, when I found Uranus and Neptune, most of the people returned to the line and waited another hour or more to see those objects. This experience taught me that the world is full of people who would like a chance to see even a small portion of the universe. Providing people with that opportunity is one of the most enjoyable and rewarding experiences I've had.

Now, I've moved back to Portland. I'm happy to be under Oregon's dark skies again and I will do everything I can to preserve them. But I also realize I have returned as a more capable amateur astronomer. I realize now that I was actually "blinded" by the dark skies here. I had looked at the same old deep-sky objects time after time and rarely tried anything new. Now I enjoy solar observing, sunspot counting, naked-eye observing, sidewalk astronomy, observing with binoculars, daytime planet observations, astronomy on the computer, and finding asteroids, double stars, and variable stars. I'm more skilled at finding difficult objects, observing double stars, and estimating magnitudes. Now I can truly see the universe.

So if you're fortunate enough to have dark skies, then please don't let them blind you. Don't look at the same objects every night. Try some new things and you'll discover exciting new areas of astronomy. They will thrill you and reaffirm your love of astronomy. No matter where you live, there's an entire universe hiding in that sky, awaiting discovery. If you live amidst light pollution, don't believe for a moment there's nothing astronomical to do. You have plenty to see even in a heavily light-polluted city. Just look. ☐

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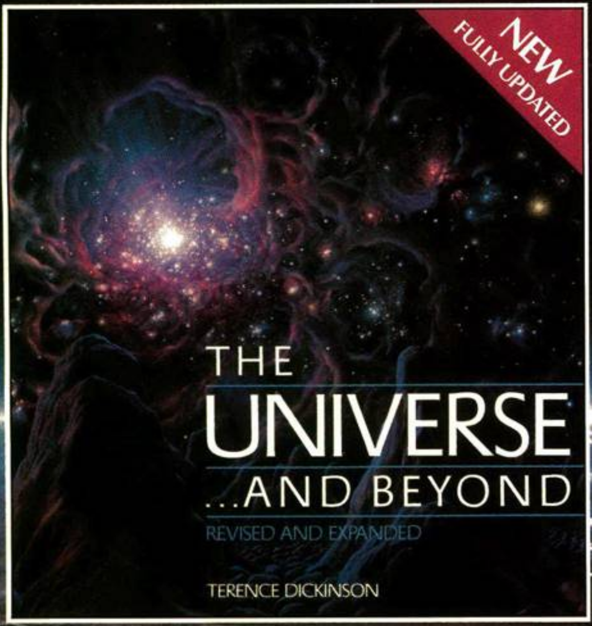

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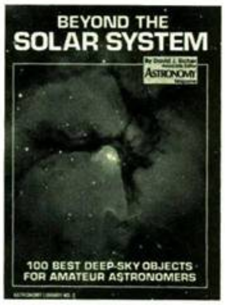

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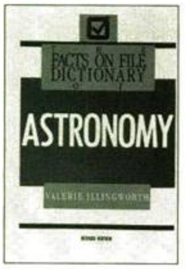

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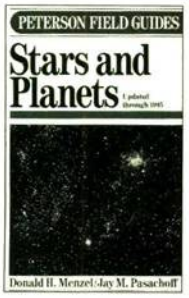

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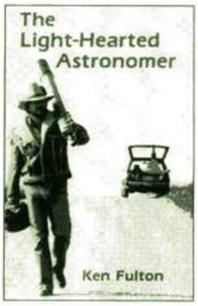

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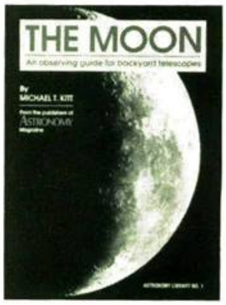

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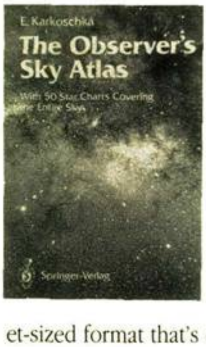

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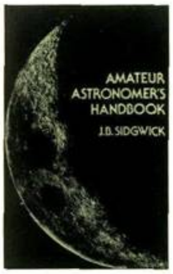

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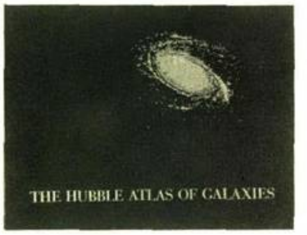

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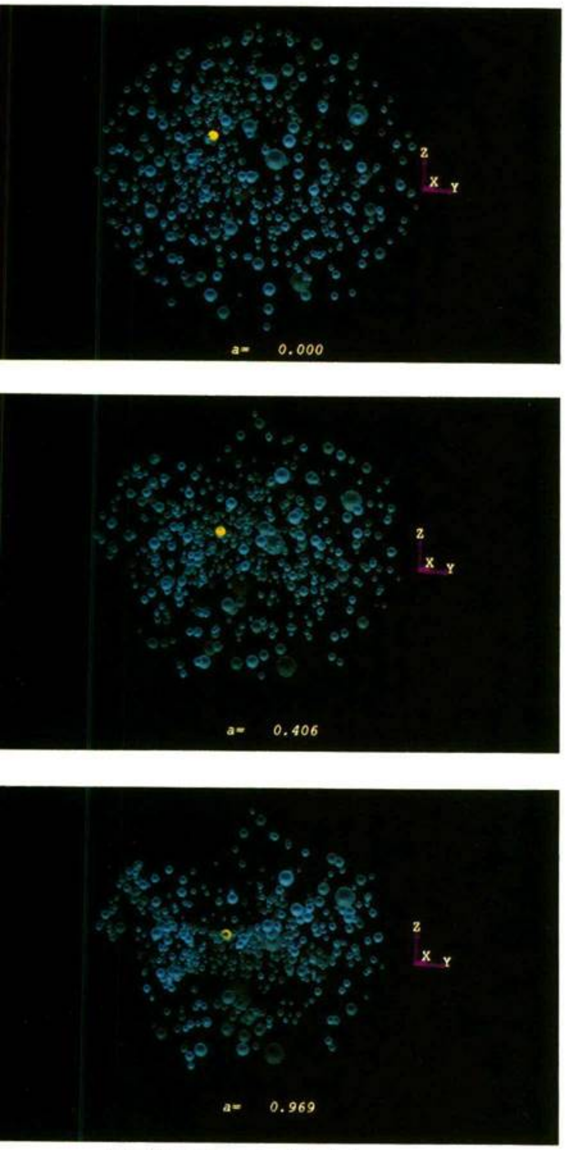

Edward Shaya, University of Maryland

THE LOCAL SUPERCLUSTER of galaxies formed from a series of gravitational encounters. This sequence of images results from a computer calculation of the motions and positions of 570 groups of galaxies in our local region of the universe. The groups start in nearly random positions almost 13 billion years ago (top) but begin to move toward the groups with larger-than-average gravity within the next 5 billion years (middle). In the final image showing present positions, the filamentary structure of our Local Supercluster is evident. The yellow dot represents our Local Group of galaxies. The expansion of the universe between the images has been removed.

Cosmologists seek to describe the state of the universe seconds, or fractions of a second, after the big bang. Observers, on the other hand, view the present structure of the universe, which is filled with voids and filamentary structures. But what did the universe look like between these times? A recent computer calculation by three astronomers traces the structure of our local neighborhood of the universe over the almost 13 billion years since its origin. (The calculations are independent of the actual value for the expansion rate of the universe, or the universe's age. The numbers quoted here assume the age of the universe is 13.3 billion years.)

Their calculation starts with the 570 known groups of galaxies, containing roughly 2,300 galaxies, presently within 100 million light-years of Earth. Using each group's observed location, distance, and speed of motion, the researchers determined the past positions of the groups using dynamics. Because the equations yielding the positions and velocities of each group need to be solved simultaneously for each time of interest, these calculations weren't possible until recent improvements in computer speed and numerical calculation methods.

The calculations by Edward Shaya of the University of Maryland, James Peebles of Princeton University, and Brent Tully of the University of Hawaii show how our local region of the universe started 13 billion years ago as a fairly random scattering of galactic groups. At subsequent times, the gravity of large groups attracted smaller neighboring groups, eventually building the highly structured pattern astronomers call the Local Supercluster.

These calculations were performed on a computer workstation on a researcher's desk. The calculations are now being expanded to include additional objects. The astronomers plan to use the results from their studies to describe the cosmological parameters of the universe. One such parameter is the density of the universe, which controls whether the universe will continue to expand forever or will someday collapse on itself in a big crunch. •

LOST "PERSEID COMET" RECOVERED

On Sunday, September 27, 1992, Japanese astronomer Tsuruhiko Kiuchi recovered Comet Swift-Tuttle (1992t). A famous periodic comet, Swift-Tuttle has not been observed since Abraham Lincoln was President. The comet's period has been in question since its last appearance in 1862, so astronomers anxiously anticipated its return over the past several years. (The original prediction had it returning between 1979 and 1983, and its non-appearance left astronomers somewhat puzzled.)

Astronomers are curious about Swift-Tuttle in part because it is the parent body of the Perseid meteor shower, the most-observed meteor event each year. The Perseids consist of debris the comet leaves behind in its orbit, which Earth crosses each August 11/12. Heightened activity in the Perseid shower over the past few years led astronomers to believe the comet might return, but no one knew for sure until last September.

Swift-Tuttle will be visible in the evening sky throughout mid-December and should be bright enough to see in binoculars. The comet's path will carry it from Hercules south into Serpens and Aquila before it slips too close to the Sun to be seen in late December.

Preliminary positions (in equinox 2000 coordinates) and magnitudes for the comet are as follows:

Nov. 1: 16h36.7m +43°35' (mag. 7.1)
Nov. 11: 17h40.0m +30°10' (mag. 6.7)
Nov. 21: 18h27.0m +16°14' (mag. 6.6)
Dec. 1: 19h01.0m +4°06' (mag. 6.6)
Dec. 11: 19h28.0m –5°41' (mag. 6.8)
Dec. 21: 19h49.5m –13°30' (mag. 7.0)

Observers on September 27 reported a magnitude of about 9 and a coma measuring 4' across. ASTRONOMY looks forward to readers' reports!

METEORITES: CHIPS OFF AN OLD BLOCK

The near-Earth passage in July 1991 of the kilometer-wide asteroid 3103 (1982 BB) enabled astronomers to view its spectrum. They found that it contained an iron-free, magnesium-rich mineral called enstatite. This mineral is also found in a group of meteorites called enstatite achondrites. Michael Gaffey, Kevin Reed, and Michael Kelley of the

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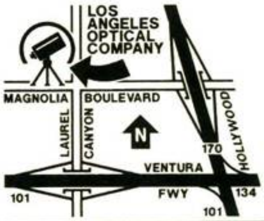

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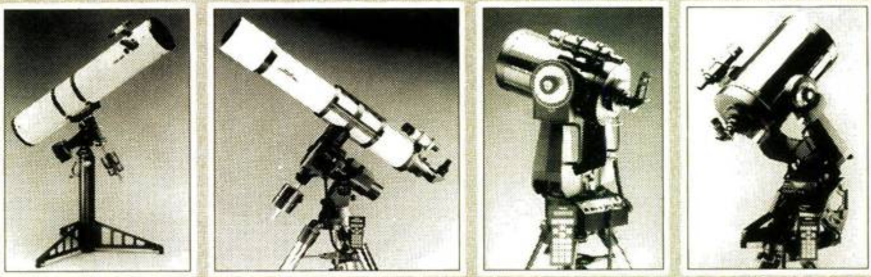

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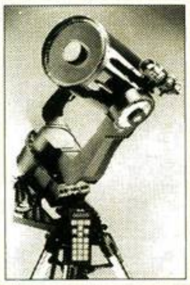

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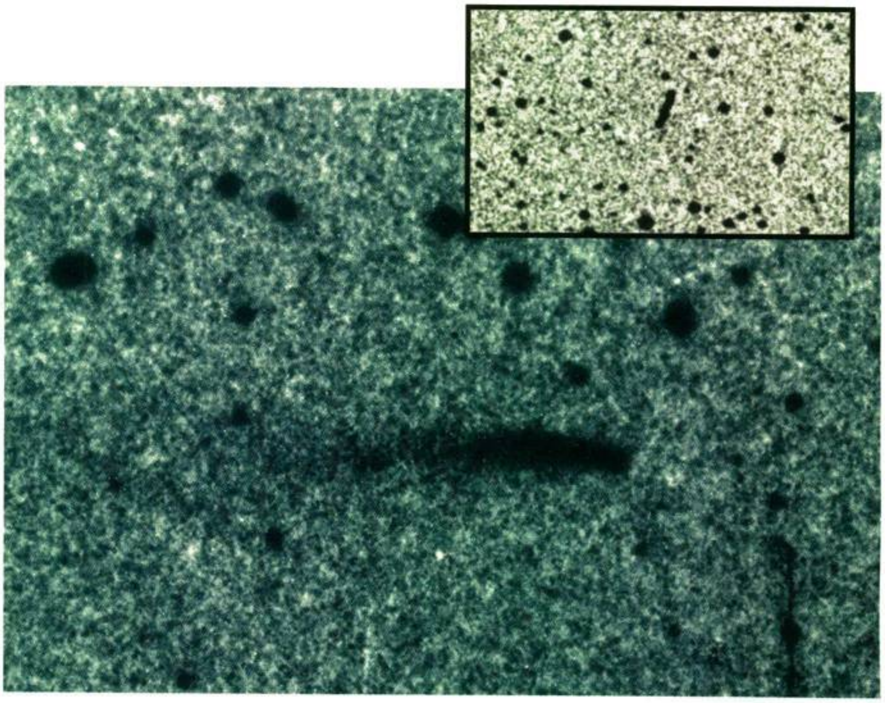


ESO, Caltech, and SERC

MINOR PLANET OR DEAD COMET? Asteroid 4015 (trailed image, right) may be an inactive, or "dead," comet. Astronomers at the European Southern Observatory recently connected 4015, discovered by Eleanor Helin in 1979, with Comet Wilson-Harrington, discovered in 1949 on a Palomar Oschin Schmidt plate (above). Between 1949 and 1979, ice coating the surface of the object apparently evaporated, leaving behind the dead nucleus seen today as a minor planet.

Rensselaer Polytechnic Institute believe the meteorites come from 3103.

The asteroid's orbit intersects the Hungaria region of the asteroid belt between Mars and Jupiter. As they reported at the annual Lunar and Planetary Science Conference in March, Gaffey's team believes that 3103 is a chip off an asteroid in this region. The collision flung 3103 into an orbit that now brings it near Earth. Linking the meteorites with their parent body will enable researchers to better study bodies formed at the junction between the inner and outer parts of the solar system.

Another research team has found diamonds in the Abee meteorite, which is an enstatite chondrite. The composition of the diamonds indicates that they were produced in the nebula from which our solar system formed, rather than from presolar material. The meteorite is unshocked so the diamonds were not produced by great pressure, unlike the diamonds found in some iron meteorites.

S. S. Russell of England's Open University and colleagues found the microscopic diamonds to represent about 0.01 percent of the meteorite's mass. They suggest that the diamonds were formed by high-energy radiation striking carbon-rich material or in the solar nebula as carbon began to condense (like the diamonds produced around stars late in their evolution). While researchers have placed much emphasis on collisions in the early history of the solar system, the Abee meteorite may indicate that low-temperature, low-pressure processes were important as well.

THE MOST DISTANT NORMAL GALAXY

The most distant galaxies known to astronomers are quasars and exotic radio galaxies. Their energetic outpourings make these active galaxies visible for much larger distances than normal galaxies. Normal galaxies appear much rarer for two reasons. First, normal galaxies are relatively faint compared to quasars, making them harder to see. Second, the large look-back times associated with quasars correspond to times before normal galaxies formed.

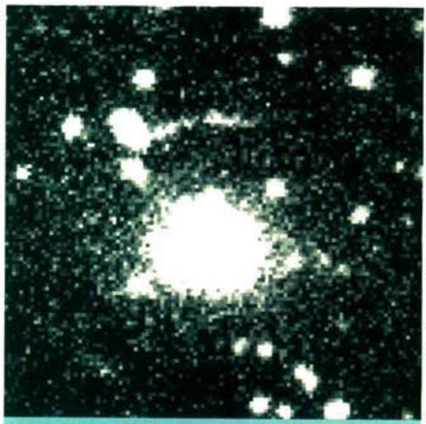
The current record holder for normal galaxies is an unnamed galaxy discovered by David Turnshek and Cyril Hazard of the University of Pittsburgh and their collaborators. The astronomers used the 3.6-meter telescope of the European Southern Observatory in Chile to look at the light coming from the quasar Q 0000–2619 (the numbers refer to the quasar's sky position). An unexpected feature in the quasar's spectrum revealed the presence of the unnamed normal galaxy.

The position of the normal galaxy's feature in the quasar's spectrum indicates that the galaxy moves away from us with a speed close to 90 percent of the speed of light (the spectral line shifted to the red by a factor of 3.428). This recession speed, or high redshift, implies that the galaxy lies 11.8 billion light-years away, assuming the age of the universe is about 13.3 billion years.

The galaxy is located near a previously discovered galaxy (of redshift 3.39) and a massive cloud of hydrogen gas that may be forming into a galaxy. The researchers continue to search for other high-redshift galaxies in this region, hoping to learn how galaxies form and clump into clusters.

METEORITE SWARM IDENTIFIED

Astronomers have long identified streams of meteors with dust ejected by comets as they orbit the Sun. Meteor showers occur when Earth passes



European Southern Observatory

REMOTE OBSERVERS discovered a gravitational lens in the compact cluster of galaxies called EMSS 2137–23. Massimo Ramella and Mario Nonino of the Trieste Astronomical Observatory in Italy observed the cluster from Trieste, using a new communications link to the European Southern Observatory's New Technology Telescope located over 7,400 miles away in La Silla, Chile. The arc at top center is an image of a galaxy located farther away than a galaxy cluster just 5 billion light-years away. The gravity of the cluster bends and distorts the distant galaxy's light to form the arc.

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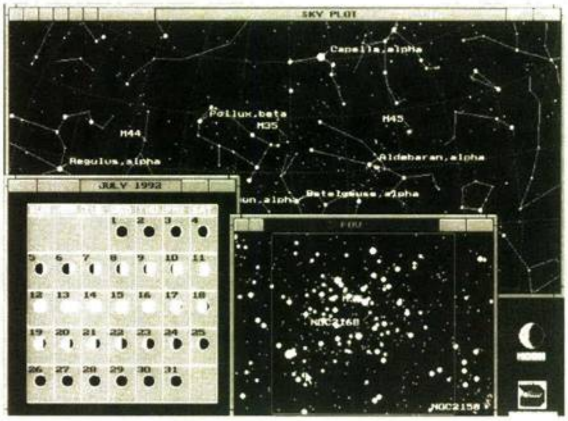
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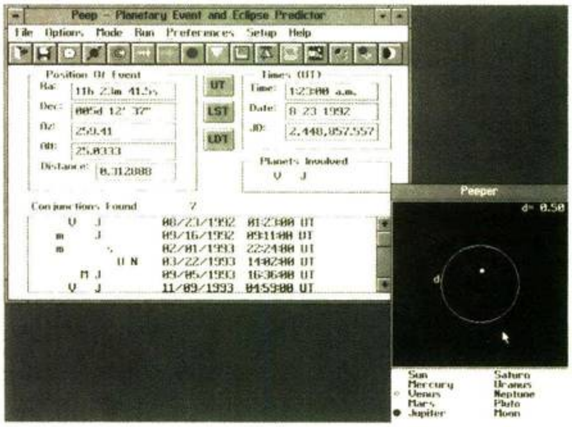
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Uranus
Neptune
Pluto
Moon

Position Of Event
Ra: 11h 23m 41.5s
Dec: 005d 12' 37"
Az: 259.41
Alt: 25.0333
Distance: 0.312000

Times (UT)
Time: 1:23:00 a.m.
Date: 8 23 1992
JD: 2,448,857.557

Planets Involved
V J

d= 0.50

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Conjunctions Found        7
    V  J           08/23/1992  01:23:00 UT
  m    J           09/16/1992  09:11:00 UT
  m      S         02/01/1993  22:24:00 UT
           U N     03/22/1993  14:02:00 UT
      M J          09/05/1993  16:36:00 UT
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through the meteor stream. These meteors are microscopic particles that do not survive the fiery plunge through Earth's atmosphere.

Meteorites, larger chunks of interplanetary matter that strike Earth's surface, do not come from these showers. Astronomers believed these rocks to be the result of Earth's random encounters with the detritus of the solar system. But Purdue University researchers now have evidence that at least some meteorites travel in swarms like the cometary dust.

The Purdue team, led by Michael Lipschutz, has identified 13 meteorites that fell from 1855 to 1895 to have come from the same orbit around the Sun. These meteorites all fell along a line on Earth's surface and have nearly identical chemical compositions. Lipschutz notes that meteorites traveling in streams may represent fragments of the same asteroid. "At the very least," he says, "these findings tell us that we don't know as much as we thought about how things get to Earth."

SUPPORTING ASTRONOMY IN THE FORMER SOVIET UNION

The American Astronomical Society (AAS) issued a plea last spring for donations to help support astronomers in the Commonwealth of Independent States, the former Soviet Union (see July Letters). By July, 356 respondents had donated $47,000. Two committees help these funds find their way to the astronomers.

The first committee, consisting of 14 astronomers from the former Soviet Union, reviews research proposals submitted by astronomers. So far they have ranked over 570 proposals according to scientific merit. They send the proposals and rankings on to the AAS FSU astronomy committee that determines which of the astronomers will receive funding. The AAS committee has granted 266 awards of $100 so far and expects to award another 100 grants this fall. (Salaries of astronomers in the former Soviet Union range from $50 to $200 per year.)

Stan Woosley of the University of California at Santa Cruz chairs the AAS FSU astronomy committee. Woosley says, "This is a one- or two-year effort. We cannot and do not intend to permanently support astronomy in the former Soviet Union. However, there is a huge cadre of talented, intelligent, and highly trained people there. The danger is that a whole generation of young, potentially productive astronomers and other scientists might be lost to changing jobs or emigration to other countries. We are encouraging the survival of a core group, people with whom we would like to collaborate in the future on international projects."

Small contributions can go a long way in supporting astronomers and astronomy in the former Soviet Union. Many publishers, including ASTRONOMY, donate copies of astronomy journals and magazines. If you wish to donate money or items such as photocopy supplies, computers, or printers, please contact the AAS FSU Astronomy Program, AAS Executive Office, 1630 Connecticut Avenue, NW, Suite 300, Washington, DC 20009.

Space News

GALILEO COMES HOME AGAIN

On December 8 the Galileo spacecraft will come racing in from deep space and skim past Earth. At 10:09 a.m. Eastern Time, Galileo will fly to within 200 miles of the surface of Earth, soaring above the Southern Hemisphere at 31,000 miles per hour. It will then depart the vicinity of Earth, heading out toward the asteroid belt and its final destination, Jupiter.

This December's encounter is the second of two Earth flybys planned into the Galileo mission (the first was in December 1990) that are designed to give Galileo some necessary gravitational kicks. At this encounter, Earth's gravity will boost Galileo's speed by an additional 11,000 miles per hour relative to the Sun, enough to allow Galileo to reach its next target, the asteroid 243 Ida in August 1993, and then Jupiter in December 1995.

However, the return of Galileo is more than just a course-change maneuver. Twelve hours before closest approach, the spacecraft will fly 67,000 miles above the north polar regions of the Moon, a part of our satellite poorly observed by previous spacecraft. Galileo's instruments will map the lunar pole and look for traces of ice in the soil.

At Earth, Galileo's best images will be of the Andes in South America. The resolution should be good enough to pick out objects 300 feet across. Scientists aren't expecting any new discoveries, but the measurements made by instruments such as the infrared spectrometer will help engineers design the various satellites of the Earth Observing System to be placed into orbit later in the decade.

However, the prime science goal of this encounter is to perform a series of precise calibrations of the instruments on the known targets of the Moon and Earth. These measurements will help maximize the return of data from Jupiter should the mission have to carry on with only the low-gain antenna as the main transmitter. The umbrellalike high-gain antenna remains only partly unfolded and unable to transmit data. But shortly after closest approach, Galileo will be as close to the Sun as it will get for the rest of the mission, making the exterior of the spacecraft as hot as it has been since the initial deployment attempt. Engineers will use the opportunity for another round of attempts to free the stuck antenna.

The pictorial highlight of this encounter comes a week after closest approach. For 16 hours, Galileo will snap images of Earth and the Moon in the same frame. The result will be a time-lapse movie showing Earth rotating as the Moon crosses the frame in front of Earth. Expected to be released by the end of the year, the movie will be Galileo's parting gift before heading off on its three-year journey to Jupiter.

RUSSIANS TO FLY ON THE SHUTTLE

Sometime in 1993, Russian cosmonauts could fly on a U.S. space shuttle and U.S. astronauts could spend time aboard the Russian Mir space station. These planned exchanges are part of an agreement signed last June between the governments of the United States and Russia. The new space agreement could also produce a unique international mission in 1994 or 1995 — the U.S. shuttle docking with the Mir station. NASA is also studying the Russian Soyuz-TM spacecraft for use as a backup crew-return vehicle for space station Freedom.

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Arthur C. Clarke,
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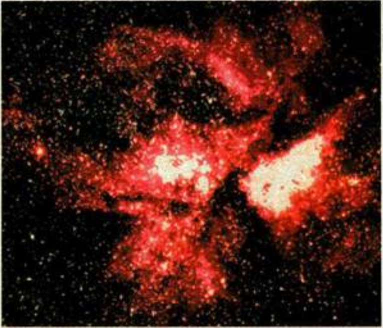


INTERNATIONAL ULYSSES COMET WATCH BEGINS

NASA is inaugurating a new international comet-watch program similar to that organized for Comet Halley. But unlike the Halley program the goal of the International Ulysses Comet Watch is to observe activity in all comets that become visible while the Ulysses mission surveys the Sun. The program is looking for backyard observers willing to monitor comets photographically.

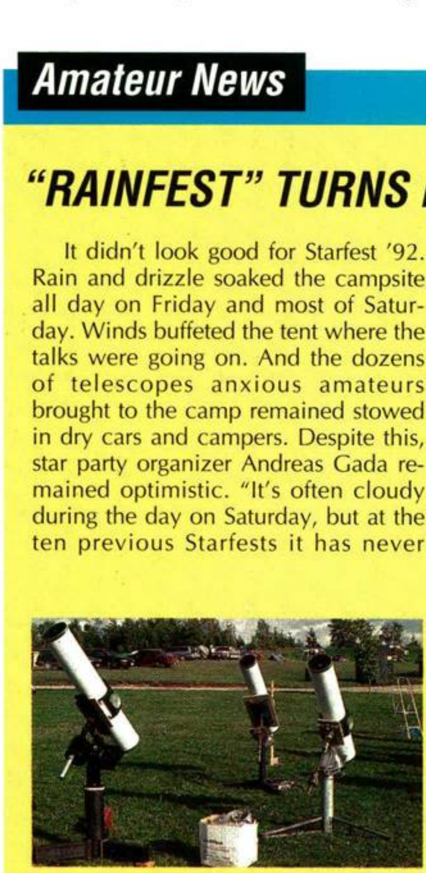
As the solar wind — a stream of charged particles — blows past a comet, the comet's plasma (or ion) tail will develop streaks, kinks, and knots like a flag flapping in a stiff breeze. Astronomers hope the photographic monitoring will let them trace variations in the solar wind's strength. These observations will then be combined with those of the Sun made simultaneously by the Ulysses spacecraft (see "Ulysses Meets a Giant," July 1992), which will pass over the Sun's south pole in 1994. The result should be a greatly improved understanding of how the solar wind behaves both in the ecliptic (the plane where the planets orbit) and away from it.

For more information about the program write to John C. Brandt, Laboratory for Atmospheric and Space Physics, Campus Box 392, Boulder, CO 80309-0392.

Amateur News

"RAINFEST" TURNS INTO STARFEST

It didn't look good for Starfest '92. Rain and drizzle soaked the campsite all day on Friday and most of Saturday. Winds buffeted the tent where the talks were going on. And the dozens of telescopes anxious amateurs brought to the camp remained stowed in dry cars and campers. Despite this, star party organizer Andreas Gada remained optimistic. "It's often cloudy during the day on Saturday, but at the ten previous Starfests it has never failed to clear up on Saturday night." Amazingly, at the eleventh Starfest the tradition continued. Right on cue at sunset on Saturday, August 29, the sky cleared and treated some 500 enthusiasts to a wonder-filled starry night.



ASTRONOMY: Alan Dyer

A TRIO OF TEST TELESCOPES provided observers at Starfest '92 an opportunity to try out their optical judging skills.

Starfest, organized by the North York Astronomical Association, is one of Canada's largest star parties. Held at a private campground near Mount Forest, Ontario, it attracts amateur astronomers from all over Ontario and Quebec, as well as Michigan and other Great Lakes states. One of Starfest's unique attractions has been the involvement each year of major manufacturers on the speaker's program. In past years, representatives from Celestron and Astro-Physics have discussed their products. This year, Sheldon Faworski of Meade Instruments described their new line of telescopes. At night, participants were able to see demonstrations of a new Meade computerized Schmidt-Cassegrain and a Meade 5-inch apochromatic refractor.

Also on the speaker's program, telescope maker and professional optician Peter Ceravolo described a series of Maksutov-Newtonian telescopes his new company will be introducing to the market over the next few months.

Amateur astronomers also had a chance to test their skills at judging optics. Organizers set up three Newtonian telescopes of known optical quality. One telescope had 1/2-wave optics (fair), one had 1/4-wave optics (very good), and one had 1/10-wave optics (superb) but only the organizers knew which was which. Out of eleven observers who completed the test, nine correctly identified the 1/10-wave telescope as the best. But six observers ranked the 1/2-wave scope as number two while seven thought the 1/4-wave scope was number three. It seemed that selecting a winner posed little problem, but sorting out the 1/4- and 1/2-wave scopes proved more difficult. However, the small number of testers made it difficult to draw any sweeping conclusions.

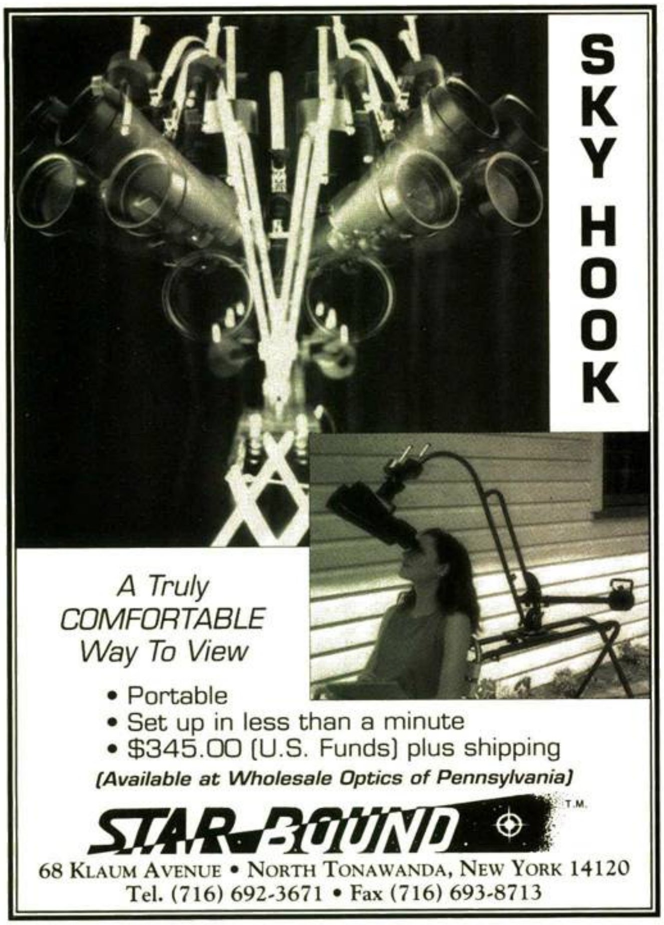
Next year's Starfest will feature a display of astrophotography, and if the tradition continues, it will be clear. Starfest '93 will be August 20 and 21. For more information contact Andreas Gada, 26 Chryessa Avenue, Toronto, Ontario, Canada M6N 4T5.

AMATEUR ASTRONOMY LOSES A FRIEND

Amateur astronomers were saddened to learn of the death of Michael Porcellino on July 31. Michael may be best known to ASTRONOMY readers for his frequent articles in these pages on amateur astronomy and astronomy club news. (His most recent offering was a series on cleaning, collimating, and polar aligning a telescope in March, April, and May 1992.)

Michael was a member of the board of directors of the Chicago Astronomical Society and was active in teaching astronomy to adults and children in the Chicago area. He ran the First Light program at the Morton College Planetarium for a number of years, bringing astronomy to hundreds of people, young and old. Michael also worked with Chicago's South Shore Cultural Center on their plans to build a public observatory. With his death, the Chicago area has lost a champion of public astronomy education.

Michael was also the author of two popular books on amateur astronomy — *Through the Telescope: A Guide for the Amateur Astronomer* and *A Young Astronomer's Guide to the Night Sky.* Through these books, Michael's enthusiasm for astronomy will continue to bring new people into the hobby for many years to come. — *Bert Stevens*



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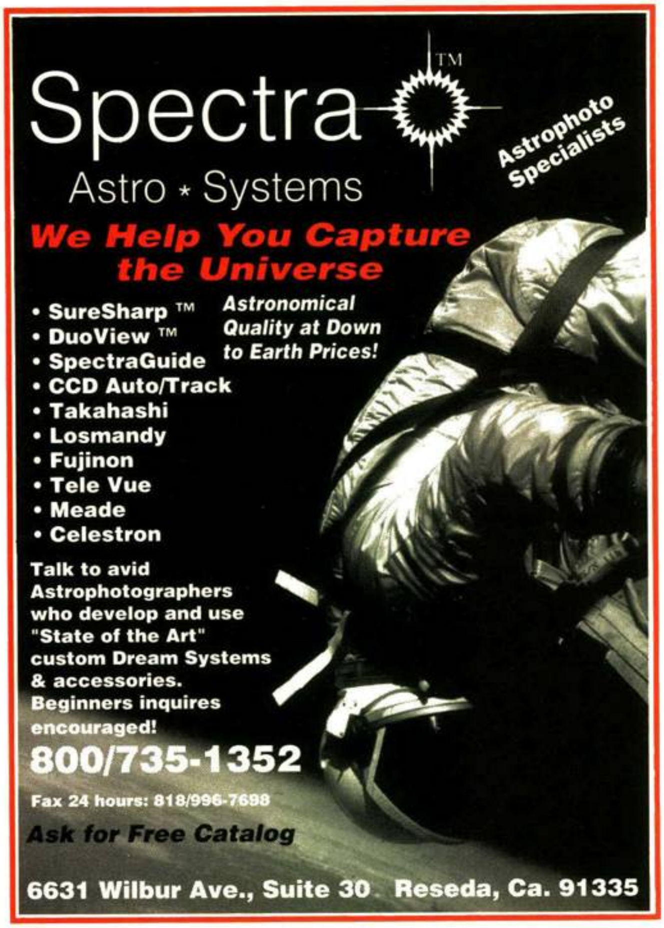

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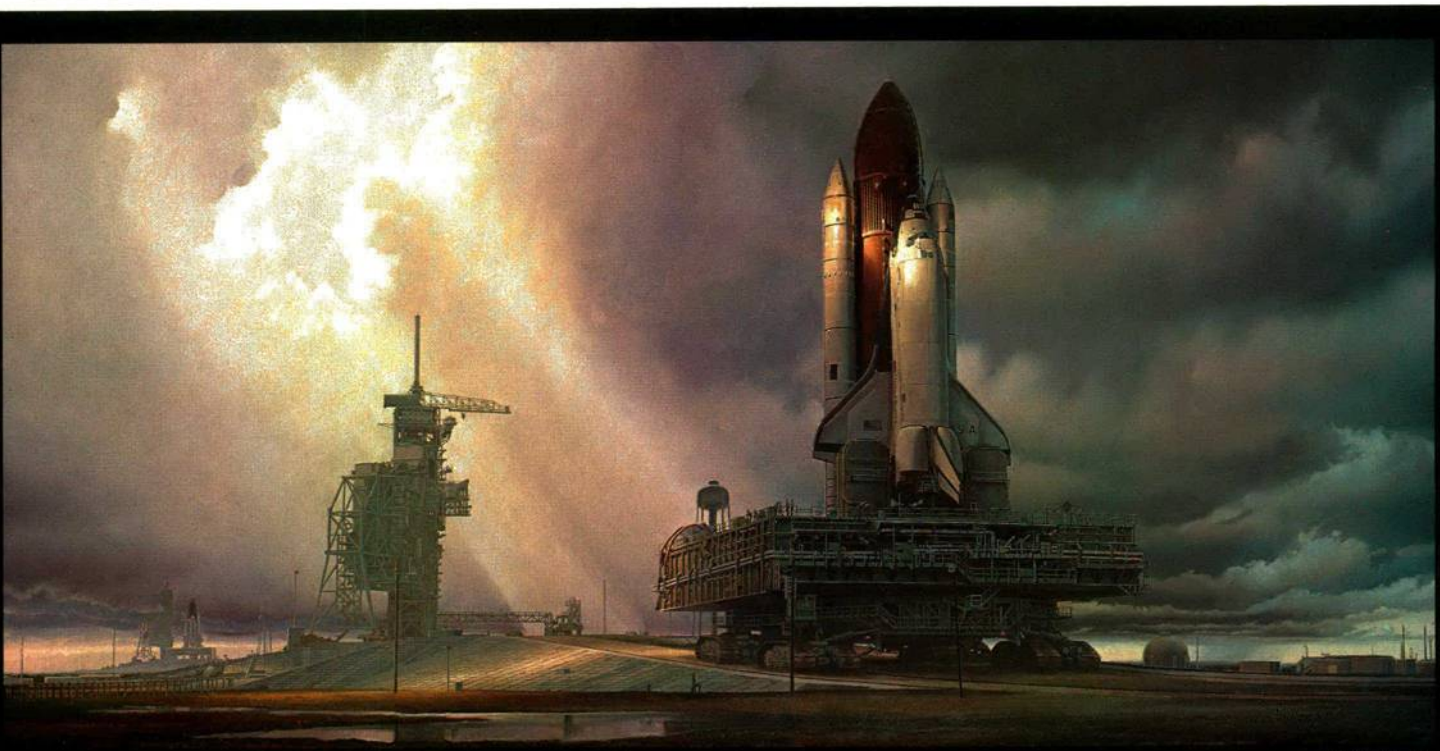

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NEW GROUP OF AMATEURS TO USE HUBBLE

Six more amateur astronomers will have a rare opportunity to use the Hubble Space Telescope. Their proposals were selected from about a hundred received by the Space Telescope Science Institute over the last two years. This is the second group of amateurs to win time on the Hubble. Six others were selected in 1989. Four of them have made their observations with Hubble and are now analyzing their results.

The second-round group of amateurs includes the following:

Nancy Cox, a nurse from San Francisco, California, who will study hot, young stars embedded in the Lagoon Nebula by taking spectra of the stars in ultraviolet light, the wavelengths at which these stars emit most of their light.

Karl Hricko, a high school teacher from Edison, New Jersey, who plans to take high-resolution images of a galaxy called NGC 4319. Next to this galaxy is a quasar, Markarian 205, that on some ground-based images appears to be linked to the galaxy by a luminous bridge of material. Yet according to the redshifts in the light from these two objects, the galaxy is 100 million light-years away while the quasar lies 8 billion light-years away. Hricko's images should help end the controversy of how far away Markarian 205 really is.

George Lewycky, a computer programmer from Milltown, New Jersey, who will use Hubble's ultraviolet sensitivity to study the distribution of nitrogen, argon, and methane in the atmosphere of Titan, Saturn's largest moon.

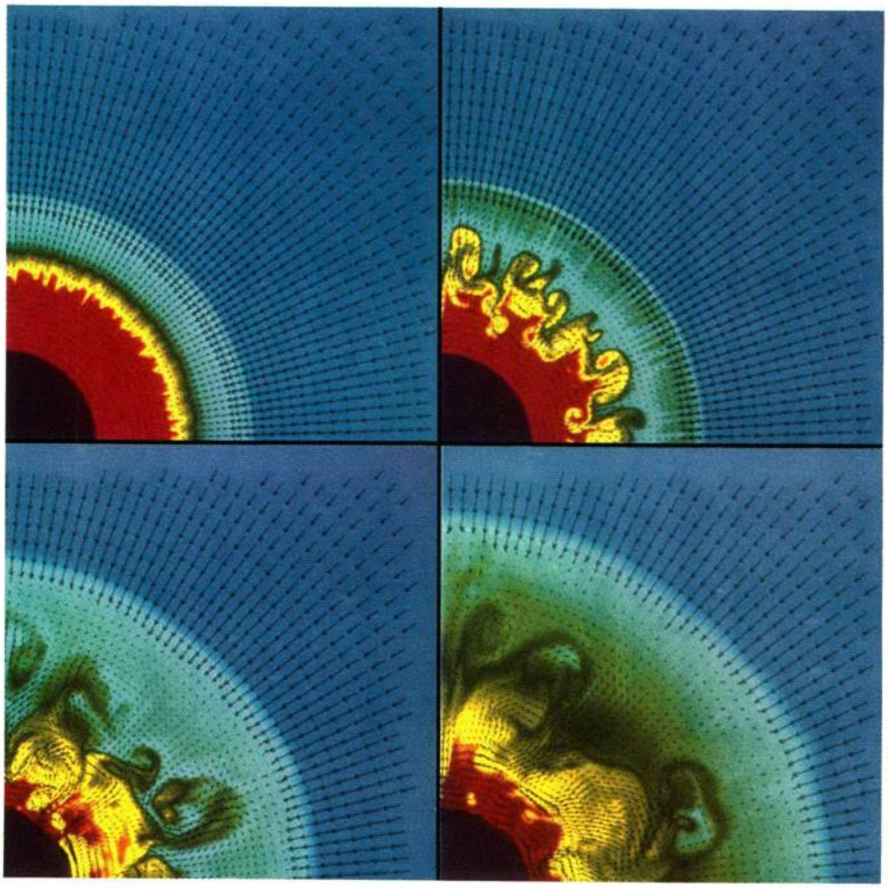
Harald Schenk, a civil engineer from Sheboygan, Wisconsin, and Jim Secosky, a high school teacher from Shortsville, New York, who will combine their separate proposals into a single project that will inspect several asteroids to look for signs that they may be emitting gases, much as comets do.

Benjamin Weiss, a student at Amherst College, Massachusetts, who will also look at several asteroids, but to discover whether those asteroids are actually binary objects with two asteroids orbiting in close proximity or even in contact.

In describing the ongoing use of the Hubble Space Telescope by amateur astronomers, Riccardo Giacconi, director of the Space Telescope Science Institute says, "I expect amateur astronomers to ask refreshing new questions. Their findings will make a real contribution to the advancement of astronomy." ☐

David Barnaby, University of Wyoming

NEW EVIDENCE FOR DARK MATTER comes from this infrared image of the edge-on spiral galaxy NGC 5907 in the constellation Draco. David Barnaby and Harley Thronson of the University of Wyoming used infrared measurements of the light coming from the galaxy to estimate its mass and the expected velocities of stars orbiting the galactic center. Comparing their estimated orbital velocities with velocities measured by Renzo Sancisi of the Kapteyn Astronomical Institute in the Netherlands, they found that the amount of mass observed was insufficient to explain the gravitational pull on orbiting stars. Although the infrared measurements made at the Wyoming Infrared Observatory enable the astronomers to penetrate the thick layer of dust that absorbs visible light, they did not find enough mass in the bulge to account for the galaxy's gravity. They conclude that a dark halo surrounding the galaxy — outside 45,000 light-years from the center — contains about 80 percent of NGC 5907's mass. Although astronomers now have a better idea of where dark matter is located in galaxies, the nature of this matter remains unknown.



Adam Burrows, University of Arizona

NEUTRON STARS ARE BORN in a fiery flash of just a few milliseconds, according to recent calculations by Adam Burrows of the University of Arizona. Using a sophisticated multidimensional computer simulation, Burrows' research shows how the collapsing core of a massive star creates a neutron star. Violent convection occurs in the core as matter at temperatures over 60 billion kelvins rushes toward the star's center at speeds of over 9,000 kilometers per second. The sequence of images shows the core at 5 milliseconds (ms) after the birth of the neutron star (upper left), 10 ms (upper right), 15 ms (lower left), and 20 ms (lower right).

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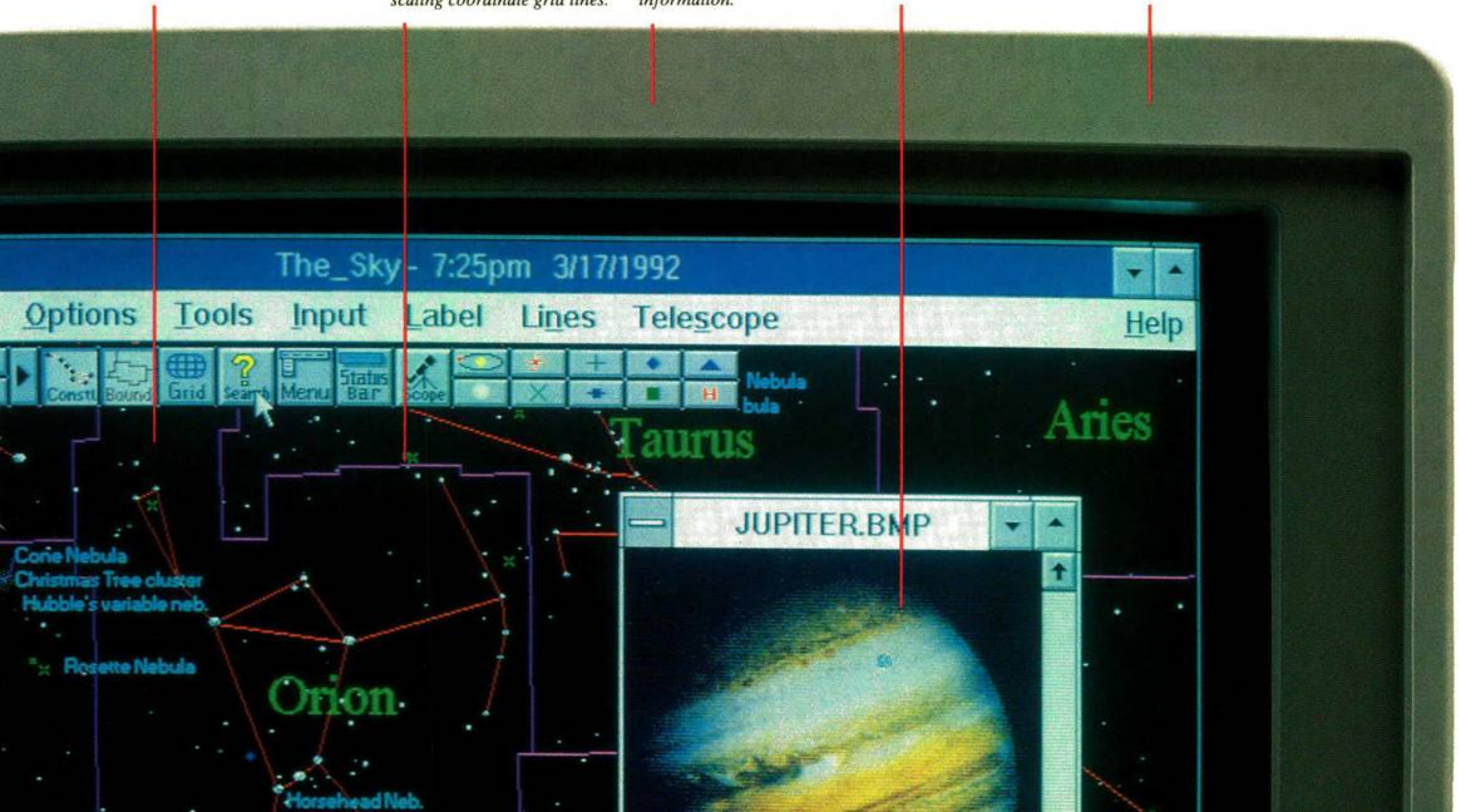
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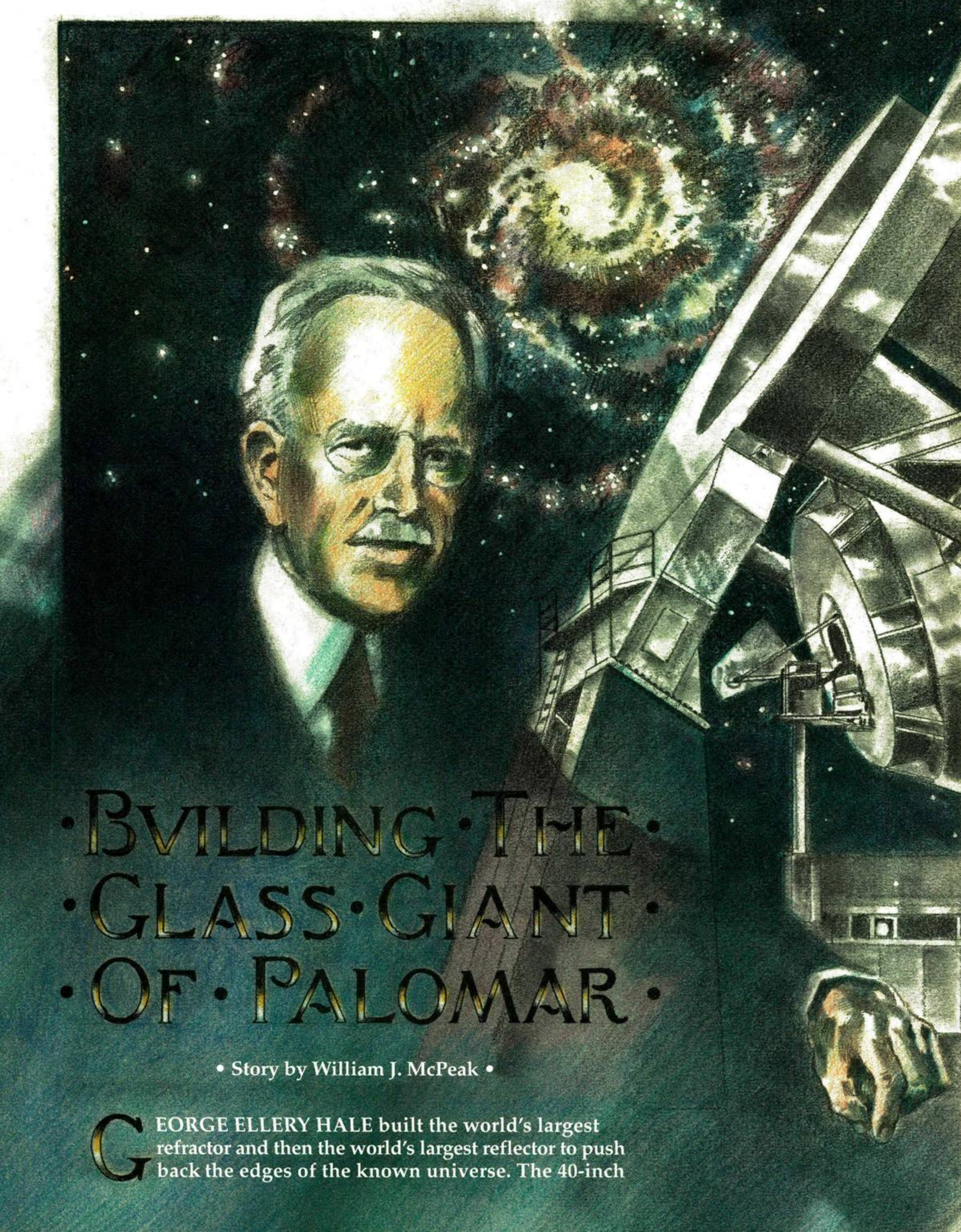
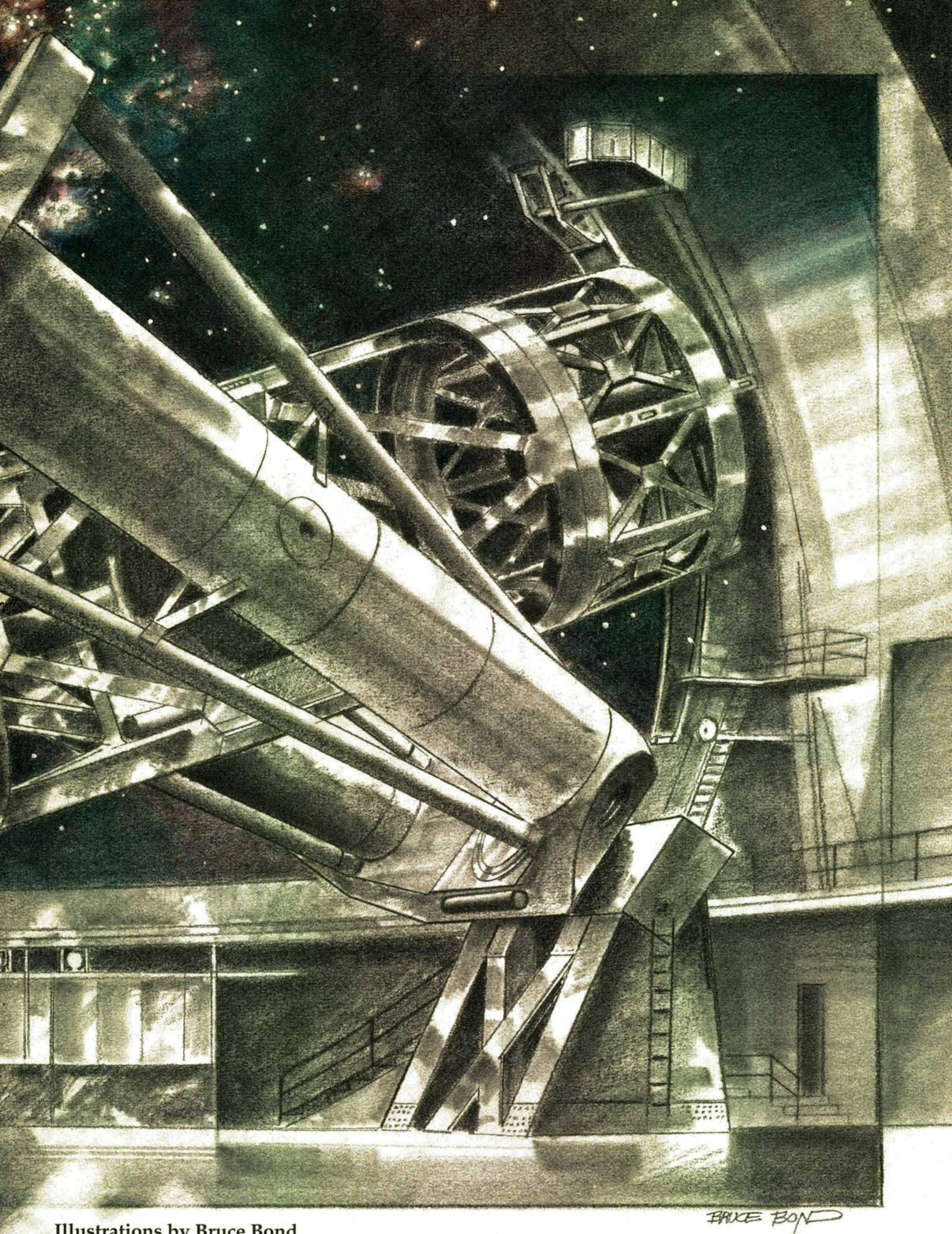
ACTUAL UNRETOUCHED PHOTOGRAPH



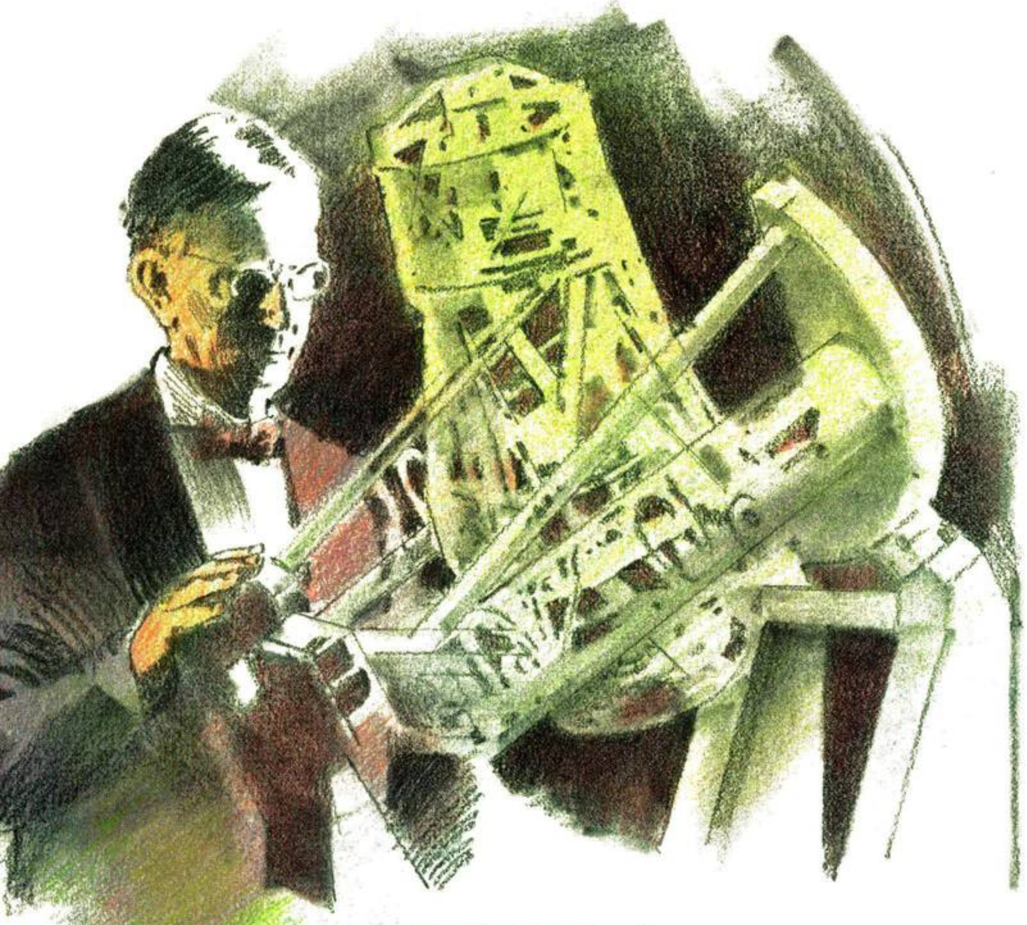
·BUILDING·THE· ·GLASS·GIANT· ·OF·PALOMAR·

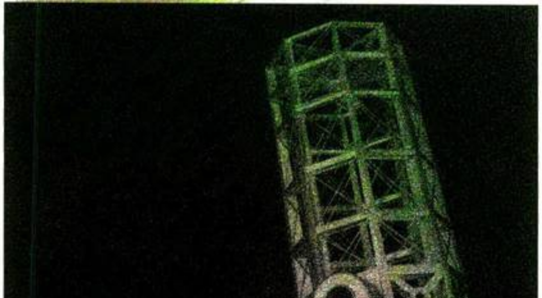
• Story by William J. McPeak •

GEORGE ELLERY HALE built the world's largest refractor and then the world's largest reflector to push back the edges of the known universe. The 40-inch



Illustrations by Bruce Bond





JOHN ANDERSON oversaw the 200-inch project from its design phase through construction. Hale's dream started as a 300-inch scope on a fork mount (left), but its mirror proved too big.

Archives, California Institute of Technology

refractor at Yerkes Observatory presented new views of stars and spiral nebulae. The 100-inch Hooker reflector on Mount Wilson was used by Edwin Hubble to show that spiral nebulae were in fact galaxies like our Galaxy. But this scope presented more questions about the universe than it answered.

It was clear that the 100-inch could not see the edge of the universe, nor could it give the view of individual stars in distant galaxies needed to determine their distances accurately. So he started to dream in the late 1920s of an even larger telescope. He wrote an article on the need for a bigger reflector in *Harper's Magazine* for April 1928.

Hale's poor health prevented him from supervising personally the construction of the new scope. But as he had done at Yerkes in the 1890s and Mount Wilson in the early 1900s, He assembled an expert staff that could solve the challenging technical problems likely to arise during the design and construction of this new telescope. At first glance the staff was an unlikely bunch, consisting of a sea captain, an arctic explorer, and a truck driver. These men had never built a scope this large — no one had — but like Hale, they were dreamers who could put ideas into steel and glass.

Captain Clyde "Sandy" McDowell, on leave from the U.S. Navy, joined the staff to manage the construction. Russell Porter — ex-arctic explorer, optician, amateur telescope maker, and architect — was selected as the team's designer. And Hale had to look no further than the Mount Wilson optical shop for truck-driver-turned-optician Marcus Brown to grind and polish the piece of glass for the telescope's mirror. But the telescope project began with the ideas proposed by the scientists Hale drew from Mount Wilson Observatory — Walter Adams, John Anderson, and Francis Pease.

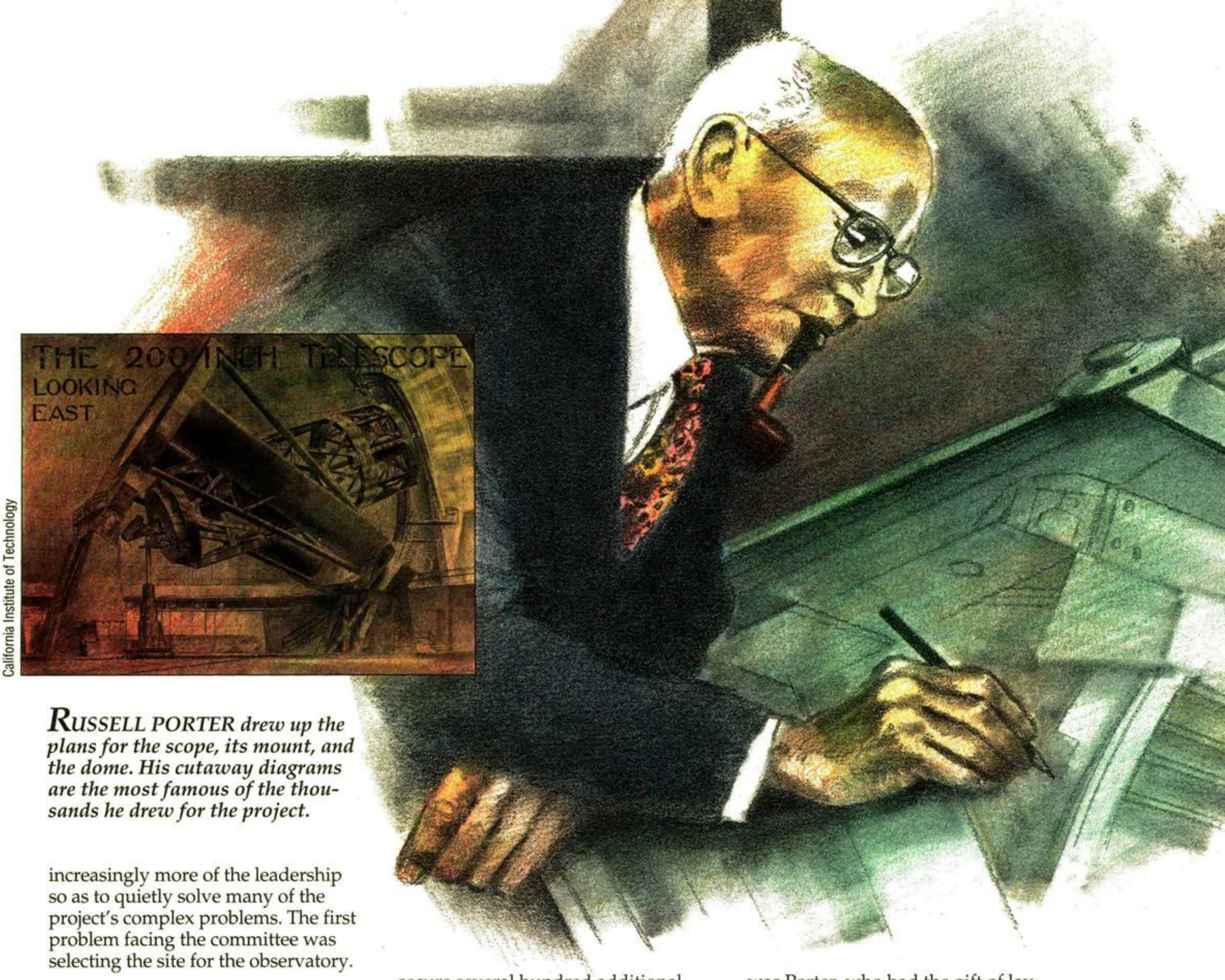
Plans for a 300-inch Scope

Hale's initial plan was for a telescope 300 inches in diameter. Pease drew up the plans for this gigantic scope, but it was quickly trimmed to 200 inches when Hale and Pease realized that they couldn't move such a large mirror from its manufacturer to the observatory.

Pease's analysis of the 200-inch scope was waiting in the wings when Hale sent a copy of his *Harper's* article to the Rockefeller Foundation, along with a letter soliciting their interest in a project to construct a large reflector. Within a few weeks he formally proposed the design for the 200-inch scope, armed with Pease's detailed report. On June 12, 1928, the Rockefeller International Education Board voted to provide $6 million to finance the telescope project. Because they didn't want the money to go to Carnegie Institution's Mount Wilson Observatory, they donated the money to the California Institute of Technology in Pasadena, California, to start an independent observatory. Several additional millions were raised to cover future operational expenses of the observatory.

The choice of Caltech wasn't coincidental. Hale helped transform the Throop Polytechnic Institute from a manual arts school into a premiere institution. Nobel laureate and physicist Robert Millikan, who performed the famous experiment to determine the electron's charge, was lured to Caltech in 1921 by Hale to become director of the Norman Bridge Physical Laboratory and head of the Institute's executive council. Arthur A. Noyes, Hale's old school chum from MIT, came to Caltech as a professor of chemistry.

With the donation from the Rockefeller Foundation, Hale formed an observatory committee of Millikan, Noyes, physicist Max Mason (president of the Rockefeller Foundation), and banker Henry Robinson. Anderson, a physicist and the optical expert at Mount Wilson, became the committee's executive officer. As Hale became ill, Anderson took on



California Institute of Technology

***R**USSELL PORTER drew up the plans for the scope, its mount, and the dome. His cutaway diagrams are the most famous of the thousands he drew for the project.*

increasingly more of the leadership so as to quietly solve many of the project's complex problems. The first problem facing the committee was selecting the site for the observatory.

Where to Build It?

The site needed careful consideration. By 1930, the lights of Los Angeles already were hampering the dark skies above Mount Wilson. The conditions of the Rockefeller grant also required a new site for the observatory. For four years, the staff tested a number of dark sky sites that promised to remain dark for a number of years. Two sites stood out above the rest, Table Mountain and Palomar Mountain.

The committe discarded Table Mountain as a possible site because it straddles the San Andreas Fault. Hale had considered Palomar Mountain previously for the observatory that was finally built on Mount Wilson. He had decided at that time against Palomar because it was too remote. But this remoteness was an asset for the new observatory. After further tests of the observing conditions, in September 1934 Anderson bought several hundred acres of land from a farmer named William Beech. Beech also helped Anderson secure several hundred additional acres from neighboring ranchers. (The observatory now owns 2,040 acres.)

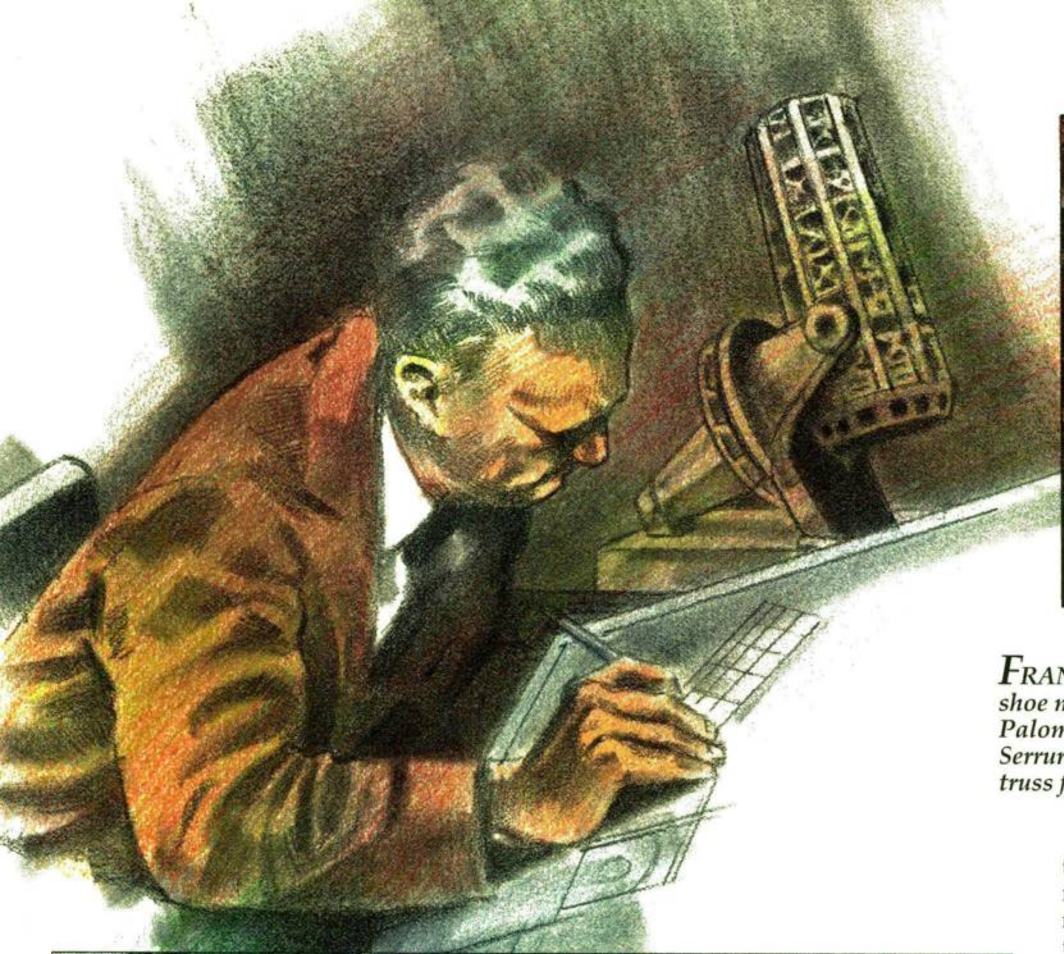
Ground was broken for the road (San Diego County Highway S6) in August 1935. With a road to the observatory in place, workers could install water mains for fire protection equipment and the electrical generators needed to build the observatory — and to power it once finished. Telephones were an uncertain form of communication for the remote observatory, so two-way radios were set up at Palomar and Pasadena.

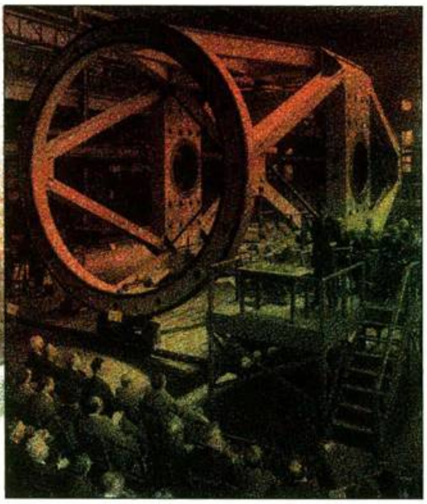
Technical innovations such as the horseshoe mount and the ribbed mirror made Hale's dream of a 200-inch scope come true.

The chief architect for the facility was Porter, who had the gift of laying down mechanical ideas in graphic reality. His cutaway sketches of the telescope quickly became famous, but they were also practical, helping the engineers determine the complex interrelationships among parts of the telescope and its domed building. More than once Porter's drafting skill and cutaway drawings resolved arguments among the project's engineers. McDowell was in charge of the telescope's construction, but the day-to-day overseeing of construction on the mountaintop fell to Byron Hill, a recent Caltech graduate.

The observatory building itself resembled the dome of Mount Wilson's 100-inch scope but didn't use the same simple corrugated sheet-metal construction. Workers drilled 23 holes 5 feet in diameter into the granite mountaintop for the steel-and-concrete foundations. The telescope had a separate foundation to isolate it from any disturbances caused by the rest of the structure.

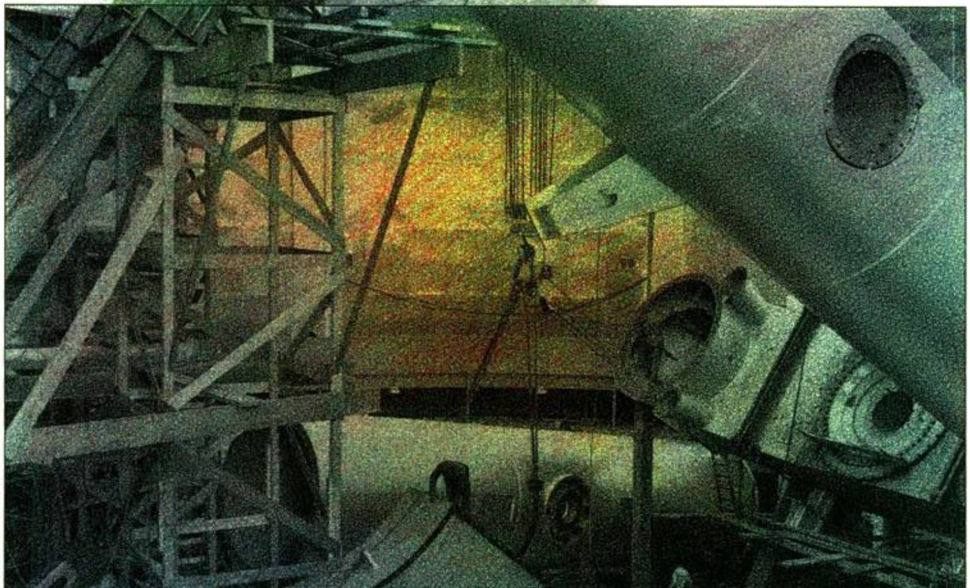
On top of the footings rose the





California Institute of Technology

FRANCIS PEASE engineered the horseshoe mount (below; reassembled at Palomar in January 1939). Marc Serrurier designed the lightweight truss for the tube (above).



Hagley Museum and Library

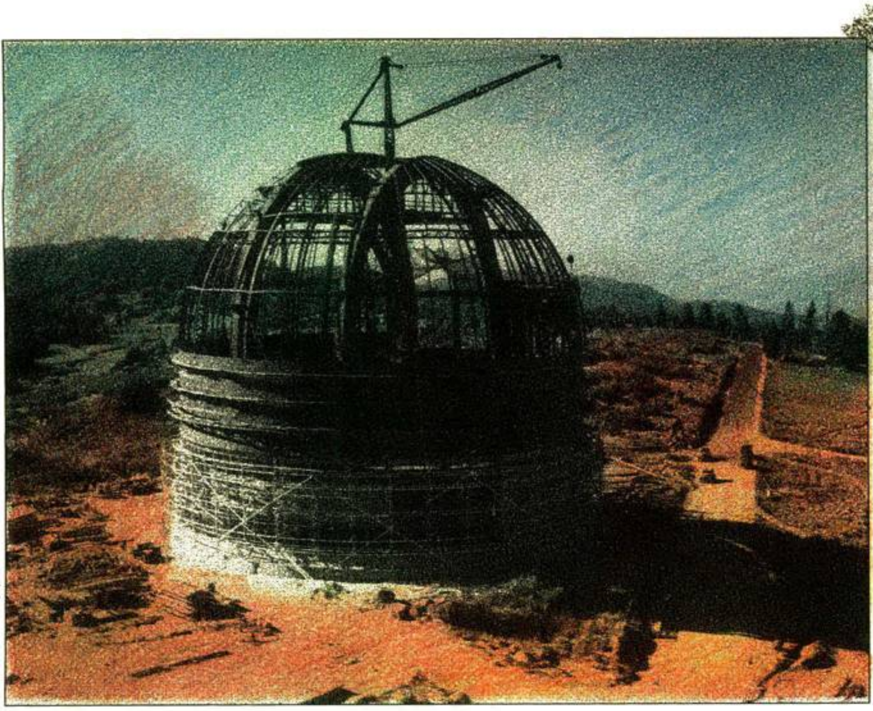
stationary base structure, a skeleton of heavily reinforced steel girders. The concrete walls were 30 feet high and actually formed two concentric rings to help insulate the telescope from daytime heating by the Sun. Railroad track laid on top of the stationary base was carefully ground smooth with a machine designed by McDowell so the dome's 32 sets of wheels would roll smoothly as the dome followed the telescope's motion through the sky.

The dome itself was one of the many innovations introduced in building the 200-inch telescope. The dome's design borrowed from the strong but lightweight design of monocoque airplane wings. Instead of covering a sturdy framework of steel girders with a thin metal skin, designers used the skin itself to contribute to the strength of the dome, reducing the number of supports needed and halving the weight of the dome to 1,000 tons. The dome skin, like the base structure's walls, was double layered to prevent heat from reaching the telescope. Two steel arches formed the opening of the 135-foot-diameter dome. The telescope would look through this slot at night, and the arches would support a crane that would assist in the construction of the telescope. After builders erected the telescope's steel pier, they completed the exterior. Work on the interior began in earnest in March 1937.

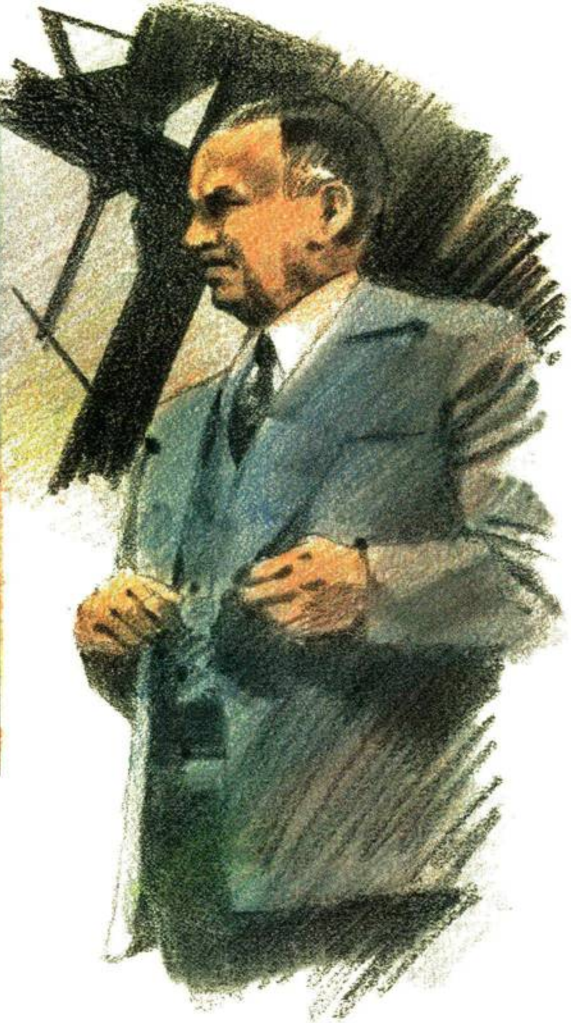
Fixing a Sagging Tube

While construction of the domed building was underway, steelworkers fabricated the telescope's tube, mount, and secondary mirror cages. Again innovation was necessary to make the telescope work.

The engineers realized that the fork mounting Pease designed for the telescope (see page 30) wouldn't support the weight of a 200-inch mirror. But the other possibility, a yoke-style mounting, would prevent the telescope from pointing toward objects near the celestial pole. Pease and Porter solved the problem by shaping the north end of the yoke into a U. This "horseshoe" mount combined the stability and strength of the yoke mount with the all-sky pointing ability of the fork mount. Redesigning the mount was only the first of the problems that needed to be solved. Roller bearings wouldn't



Official U.S. Navy photo from the Archives, California Institute of Technology



CAPTAIN "SANDY" McDOWELL ***was in charge of construction. The 1,000 ton double-skinned dome, built in 1937, spans 135 feet and rides on railroad tracks.***

support the 46-foot horseshoe. The mercury bearings that worked on Mount Wilson's 100-inch required too much mercury and would be too costly. Eventually an outside consulting firm suggested oil floatation bearings. Two 4-foot-square oil pads float the entire horseshoe on an oil film a few thousandths of an inch thick and with less friction than roller bearings. In fact, there is so little friction that a motor of only 1/650,000 of a horsepower can turn the 500-ton telescope, although a larger motor actually performs the task.

Building the horseshoe and other telescope parts also presented a problem. They were considerably larger than many companies could build. Westinghouse's South Philadelphia plant took on the challenge; it had the advantage of being located on the Delaware River, with access to the Atlantic Ocean. Transporting the parts by rail wasn't possible. The tube itself weighed 125 tons and was over 60 feet in length and 22 feet in diameter. It and other large parts such as the horseshoe had to travel to California by ship via the Panama Canal.

The horseshoe, weighing over 150 tons, needed a smooth surface to float on the oil bearings. Workers disassembled the horseshoe and sent it to Westinghouse's East Pittsburgh plant, which had a giant grinding machine that had been used for the Boulder Dam project. The surface was ground to a precision of five thousandths of an inch. That was no small feat for a 46-foot assembly, especially when daily temperature changes in the plant expanded the steel by 13 thousandths of an inch.

The tube also required innovative design. Normally, telescope tubes are made very rigid to keep the optics at both ends of the tube in alignment. But for the 200-inch telescope such a tube would be excessively heavy. Even by keeping the focal length of the mirror as short as possible (660 inches for a focal ratio of f/3.3) the tube was massive. Without the rigid framework of steel, though, the tube would sag, pushing the optics out of alignment and rendering the telescope useless.

Building the huge telescope and mount was relatively easy. Making the giant mirror was another story.

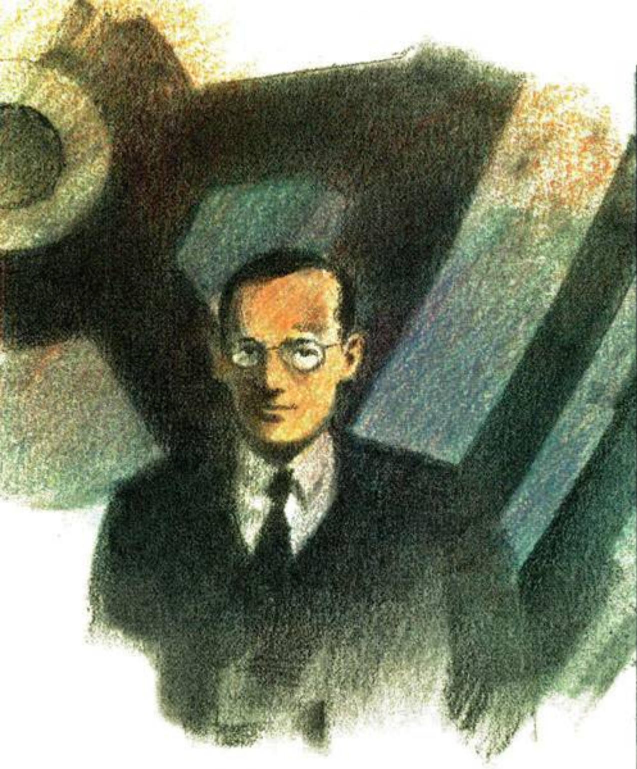
Mark Serrurier, a Caltech graduate and civil engineer who had worked on San Francisco's Bay Bridge, solved the problem with a design now known as the Serrurier truss. (See opposite.) He let the tube sag to keep the tube's weight down, but made each end sag by exactly the right amount to keep the optics in alignment. Almost all large modern telescopes use this basic design.

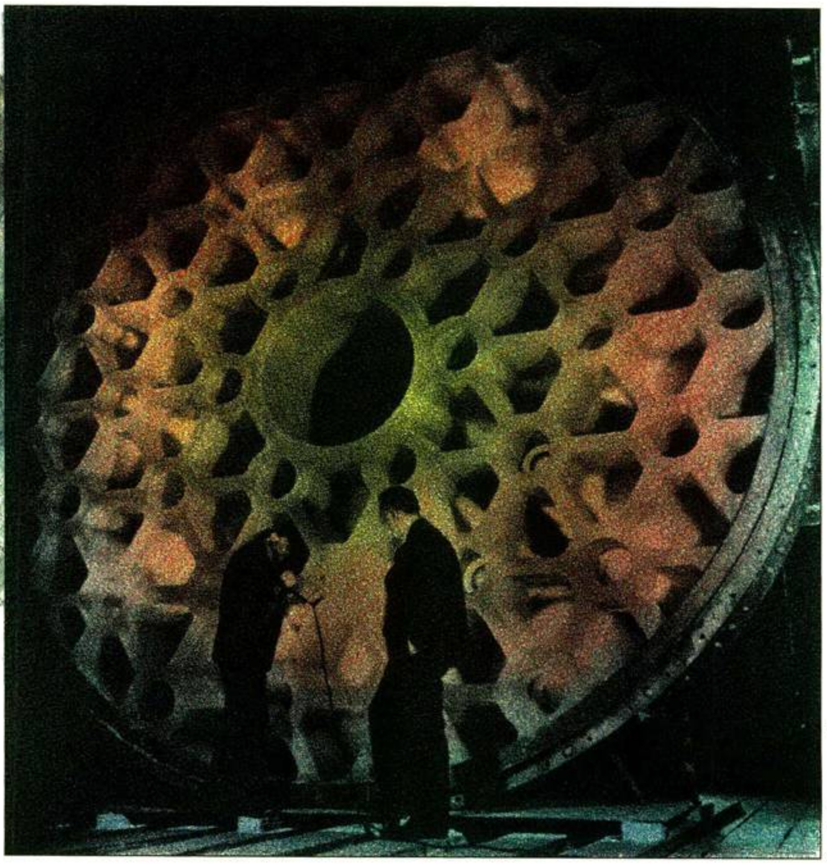
A ceremonial "last bolt" was inserted in the tube in April 1937 and it became the largest single object ever transported by ship up to that time. It joined a progression of parts that arrived in San Diego. The pieces made their way up the mountain in truck convoys — in case one cab broke down, another was there to continue.

The telescope started to take shape on top of Palomar during late summer of 1938, making that an exciting year. However, it was also a year of sadness. The original designer of the 200-inch scope, Francis Pease, died in February. On the 21st of the same month Hale died, unable to see his greatest dream fulfilled. Sinclair Smith, the designer of the telescope's drive system, also died in 1938.

Despite the losses, Anderson and the others carried on. Assembly of the telescope mounting and tube proceeded methodically. The prime-focus cage was finally hoisted into place in late 1941.

From the beginning of on-site construction, Anderson was as con-





MARCUS BROWN was the head optician for the 200-inch mirror. Corning's George McCauley (right) overcame many problems to produce the ribbed mirror.

spicuous on the mountain as Porter, the two roughing it in makeshift campsites that evolved into military-like tent encampments and finally into series of wooden buildings. Anderson's executive position on the observatory committee also required that he commute back to Pasadena often to supervise other crucial parts of the telescope's construction, such as the mirror. The making of the prodigious blank proved to be a Herculean task.

Making the Giant Eye

Experience with the 100-inch telescope at Mount Wilson showed it was important to have a mirror that was insensitive to changes in temperature. Quartz was the first choice of the committee but a year of tests resulted in unsatisfactory mirrors. In late 1931 Hale and Anderson decided to try a new glass that expands only slightly when the temperature changes. Called Pyrex, it was developed by the Corning Glass Works in Corning, New York. Several small telescopes already used this new glass, but could Corning cast a 200-inch mirror?

Immediately a problem arose: a solid 200-inch mirror would weigh 40 tons — too heavy for a telescope. Glass expert Arthur Day, of the Carnegie Institution of Washington, suggested that the mirror have a ribbed back to reduce its weight. Pease designed such a mirror and the support structure to hold it in the telescope.

Corning turned the mirror project over to George McCauley. In 1932 using small disks, he started to try out the properties of the special mixture of the new glass to be used for the 200-inch mirror. One of these was the 30-inch ribbed mirror for the telescope's coudé optical train.

To start the 200-inch mirror, Corning built a beehive structure in which to cast the glass. A second beehive built out of firebrick to withstand 2300° F temperatures would anneal the glass. Anchoring the silica brick cores of the ribbed-mirror mold proved to be most difficult. The molten glass for one blank was wasted when it melted the cement in the mold, sending the cores bobbing to the surface of the glass.

After two more tries, McCauley realized he had to build an entire furnace, not just a casting beehive, to hold the mirror and heat the sluggish glass to the proper temperature. Glassworkers tried the new furnace out on a 60-inch secondary mirror for the telescope. Once again a core broke loose. Though the mirror blank was still useable, such a problem would ruin the 200-inch disk.

By March 1934, everything was ready for the pouring of the 200-inch mirror. Again several cores broke loose. McCauley redesigned the cores using a new holding bolt and a cooling mechanism to keep the bolt from melting under the high temperature of the glass. On December 2, 1934, glassworkers cast a second 200-inch mirror. During the next ten months, the blank slowly cooled in the annealing oven. Even these times were tense as floods and an earthquake threatened the mirror.

An additional two months of preparation were necessary before the mirror was ready for its 3,000-mile journey by rail to Caltech. People lined the tracks along the route in the spring of 1936 to see the flat car with the mysterious container labeled as the 200-inch mirror.

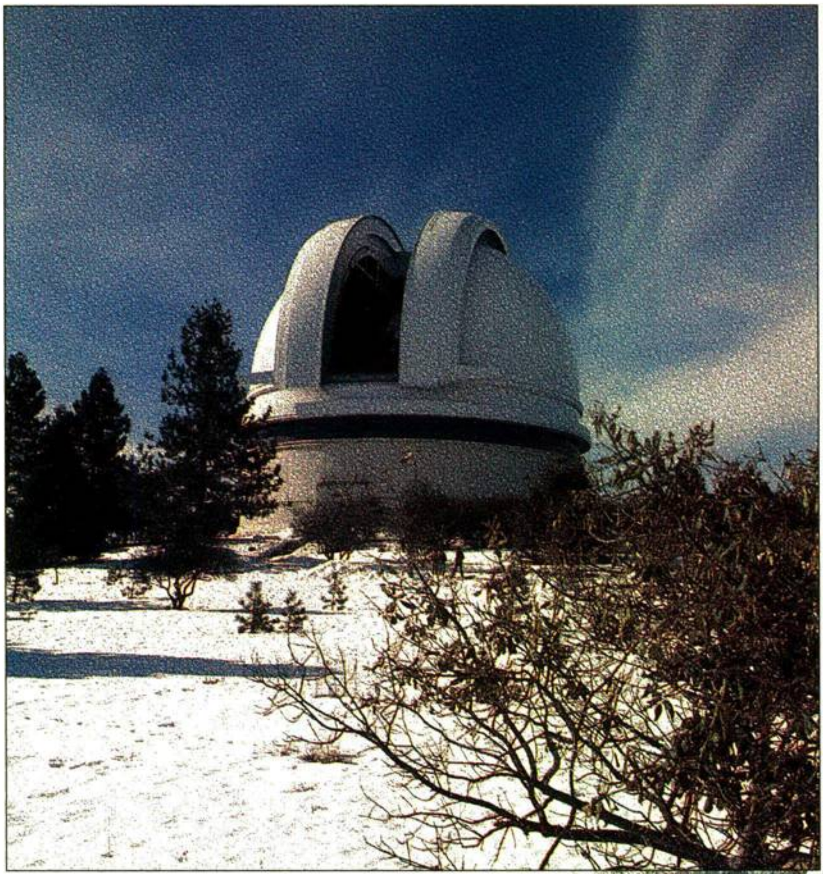
Anderson and Brown had been busy preparing for the mirror's arrival. Caltech didn't have an optical shop before the 200-inch project, so Brown assembled and trained the op-ticians needed to grind and polish the mirror. In April 1936, Brown guided the mirror into the shop after its long journey from New York. Soon after, the opticians started to remove 5 tons of glass to make the blank into a short-focus mirror.

The United States' entry into World War II in 1941 stopped work on the mirror. After the war, fine grinding resumed. Then the opticians cleaned the mirror for more than three months before starting to polish its surface. Final polishing and aluminizing would wait until the mirror could be tested in the telescope.

November 18, 1947, was the long-awaited day when the mirror, loaded on a 24-wheel trailer, began the two-day trip — at nearly walking speed — from Pasadena to the top of Palomar Mountain. For a melodramatic touch, as the procession plodded along Highway 76 toward the mountain, a freak ice storm began to whip up. To everyone's relief the mirror arrived safe and sound at the service entrance to the observatory before the sleet did.

With the mirror in place, astronomers began testing the optics, the dome control, and the mount and its drive. First light occurred in January 1948.

On June 3, 1948, Caltech president Lee DuBridge dedicated the Hale Telescope as 300 guests looked on. Hale had died 10 years before, but it was fitting that this monumental instrument be named after the astronomer whose vision gave it birth.



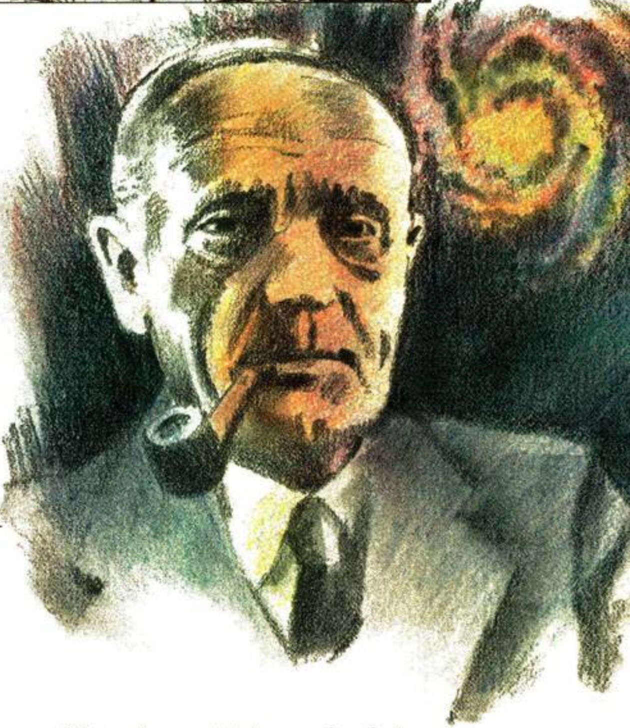
Dennis Stowell

Hale's Legacy

The telescope wasn't built by Hale, nor did he design the scope or its building. His great talent lay in finding the right people for the job and convincing them that they should work on the project. For example, Sandy McDowell gave up a chance at promotion to admiral to oversee the construction of the telescope. Hale also had a knack for finding money for large projects, and for the extra bit of funding required when a project started to stall due to unforeseen problems.

We should recognize others for their equally important contributions — Anderson, Brown, McCauley, McDowell, Pease, and Porter, to name just a few. Without their innovative designs and expertise, the telescope might not have been built.

While the 200-inch scope is a fitting memorial to Hale and his contributions to astronomy, it isn't just a historical monument raised to the memories of the scientists and engineers. The scope remains a working instrument that continues to push back the frontiers of astronomy. It has expanded the visible universe, in part through the work of Edwin Hubble on the distances of galaxies. Walter Baade's study of Cepheid-type variable stars in the Andromeda Galaxy showed that the universe was twice as large as previously thought. The nature of quasars was uncovered at Palomar Observatory and continues to be a topic of research there today. Astronomers keep the telescope on the cutting edge of technology, having integrated the scientific instruments with progressively more efficient CCD cameras since the early 1980s.

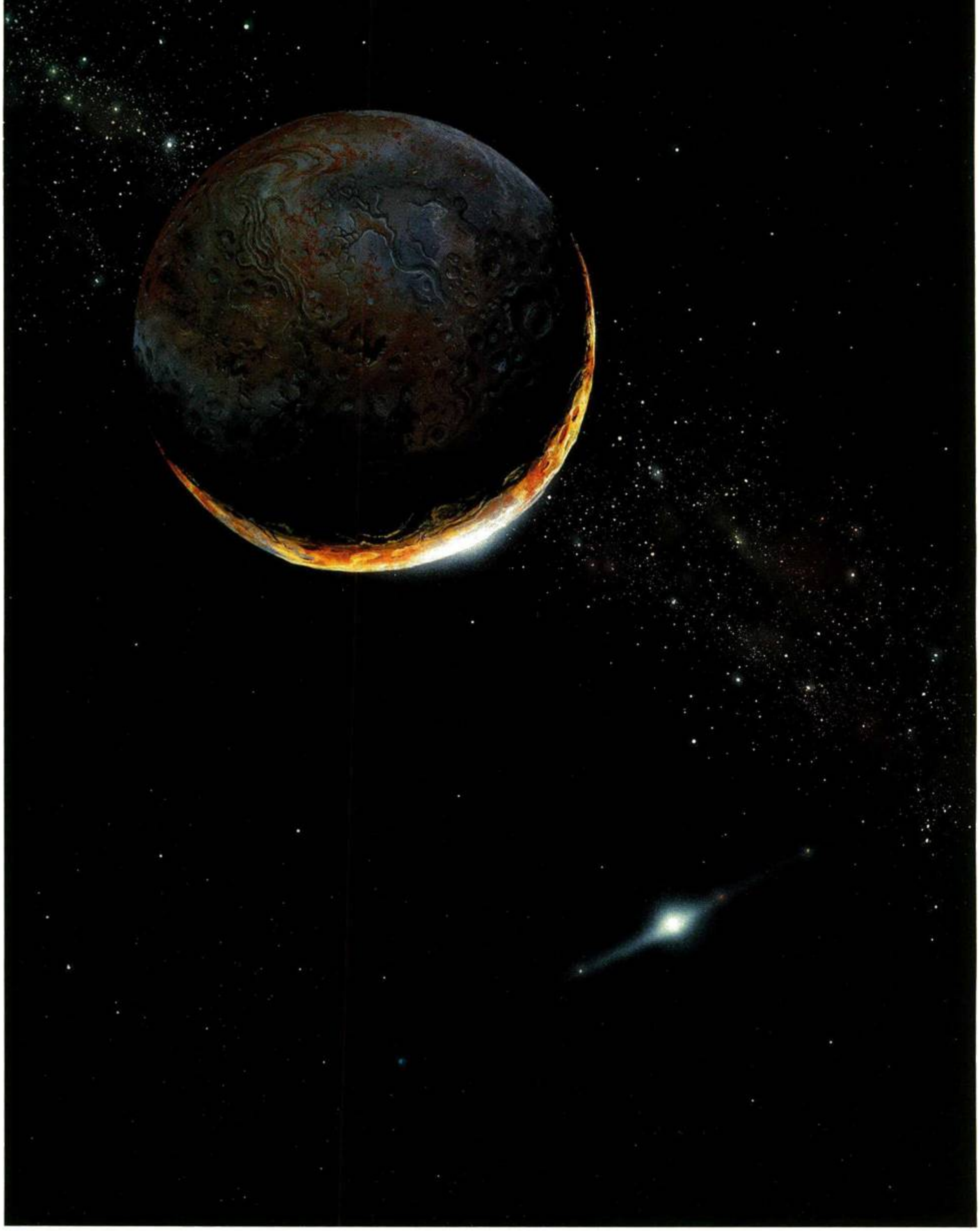


EDWIN HUBBLE used the 200-inch telescope to show that the universe was at least twice as big as determined from observations made with 100-inch telescopes.

Today the urban sprawl of San Diego and Los Angeles slices away at the wedge of darkness visible from Palomar. Instead of struggling against the technical challenges to build the 200-inch, astronomers now wage a political battle to keep Palomar's skies dark enough to continue their research. And other observatories are building newer, larger telescopes to probe out toward the edge of the universe, taking up the challenge for which the 200-inch was first built and continues to strive. In the minds of many of us, however, Hale's 200-inch will remain the world's largest telescope. □

Hale built the 200-inch to push back the edges of the universe, a task the scope continues to pursue today.

William J. McPeak is a historian of science and wrote "Tycho Brahe Lights Up the Universe" in the December 1990 issue.



Michael Carroll

SOLAR SYSTEM DISCOVERY

A NEW MEMBER OF THE FAMILY

Astronomers discover a large icy body — perhaps a "miniplanet" — on the edge of the solar system.

by David J. Eicher

Two astronomers at the University of Hawaii have found an object orbiting in the outer solar system beyond Pluto. Designated 1992 QB1, the object is now the most remote member known in the solar system. If the object reflects light as well as a comet nucleus does, then it has a diameter of about 200 kilometers. The discoverers, David Jewitt of the University of Hawaii and Jane Luu of the University of California at Berkeley, were searching for just such an object.

"We're absolutely delighted with the discovery," says Jewitt, who leads an ongoing search for such objects. "Because 1992 QB1 is so distant, the Sun's radiation affects it very weakly, changing its structure very little over eons. This means it may be the greatest time capsule we know of."

Astronomers have long dreamed of finding something at the edge of the solar system. Recently they have pinned their hopes on Planet X, thanks partly to Clyde Tombaugh. Since he discovered Pluto in 1930, wobbles in the orbits of the outer planets (real or not) coupled with human imagination suggested the existence of other, more distant planets. Jewitt and Luu's finding has revised the theory of the outer solar system. Instead of finding a large planet, they spotted a smaller object — perhaps a "miniplanet," probably made of dirty ice.

Their discovery, along with several earlier discoveries, suggests that Planet X may *not* exist. Instead, 1992 QB1 strongly points toward the existence of the Kuiper Belt, a disk of 1992 QB1-like objects and smaller icy bits of debris believed to lie outside Pluto's orbit, hypothesized by Dutch-American astronomer Gerard Kuiper. This disk may also harbor one of the deep-frozen secrets of the solar system: the source of short-period comets. (See "Where Has Pluto's Family Gone?" by Alan Stern, September 1992.)

"The discovery makes perfect sense. It's so natural," says Luu. "We wouldn't expect the outer solar system to be completely empty. Where would all of the new comets come from after so many years? There has to be an enormous source of fresh cometary nuclei."

Jewitt and Luu searched only about 2 square degrees along the ecliptic, the band of sky along the plane of the solar system. Since 10,000 square degrees of ecliptic exist, many more such objects may be awaiting similar discoveries.

They made their discovery on August 30, 1992, using the 2.2-meter telescope on Mauna Kea, Hawaii, and a sophisticated CCD camera. Success came after searching for five years for just such an object. Their equipment records objects as faint as magnitude 25; 1992 QB1 glowed faintly at 23rd magnitude at discovery.

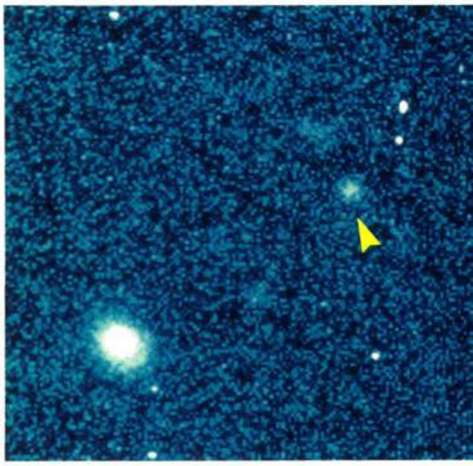
"It was bright enough that we were confident it was a real object," says Luu. It is probably the first identifiable member of the proposed Kuiper Belt and lies at a distance of between 37 and 59 astronomical units (AUs) from the Sun. (The object's great distance means that it moves slowly in the sky, and therefore several months will pass before astronomers can accumulate enough observations to calculate its precise orbit.) Both Neptune and Pluto, by comparison, are currently about 30 AUs from the Sun.

The object's color, a dark red, agrees with the model of an iceball covered with organic soot, which given eons of solar radiation, turns red. Based on the brightness, color, and assumed albedo — degree of reflectivity — Jewitt and Luu propose that 1992 QB1 might measure 200 kilometers across.

Some astronomers are even more excited than the discoverers. Alan Stern of the Southwest Research Institute in San Antonio, Texas, proposed several years ago that tens of thousands of bodies termed icy subdwarfs probably exist on the fringes of the solar system. Stern argues that Pluto, its moon Charon, Neptune's moon Triton, Saturn's satellite Phoebe, and the iceballs 2060 Chiron and 5145 Pholus (1992 AD) all share a common origin that differs from that of the rockier planets and asteroids. Says Stern: "This object is big enough that it ought to be round. It's right on the border of being classified as a planet."

Long ago, Stern contends, thousands of these objects may have inhabited the solar system before accreting into the existing planets or being pushed out into the Kuiper Belt. "We couldn't have expected the outer solar system to be completely cleaned up," says Stern. "The scene of the crime is just too complicated."

Stern foresees an era of discovery of subdwarfs, or miniplanets, ahead. Says he: "This discovery is equivalent to that of Ceres, the first asteroid, in 1801. The starting gun has now been fired." Comet astronomer Paul Weissman of NASA's Jet Propulsion Laboratory agrees: "If the orbit holds up and 1992 QB1 is distant, then it's clearly the first detection of a Kuiper Belt object and the Belt may hold millions more objects like it extending several hundred AUs outward. It's another piece of the puzzle that fits in very nicely. This heightens everyone's interest. All of a sudden it isn't just a fruitless search. It says plainly that if you go and look harder you're going to find more objects."



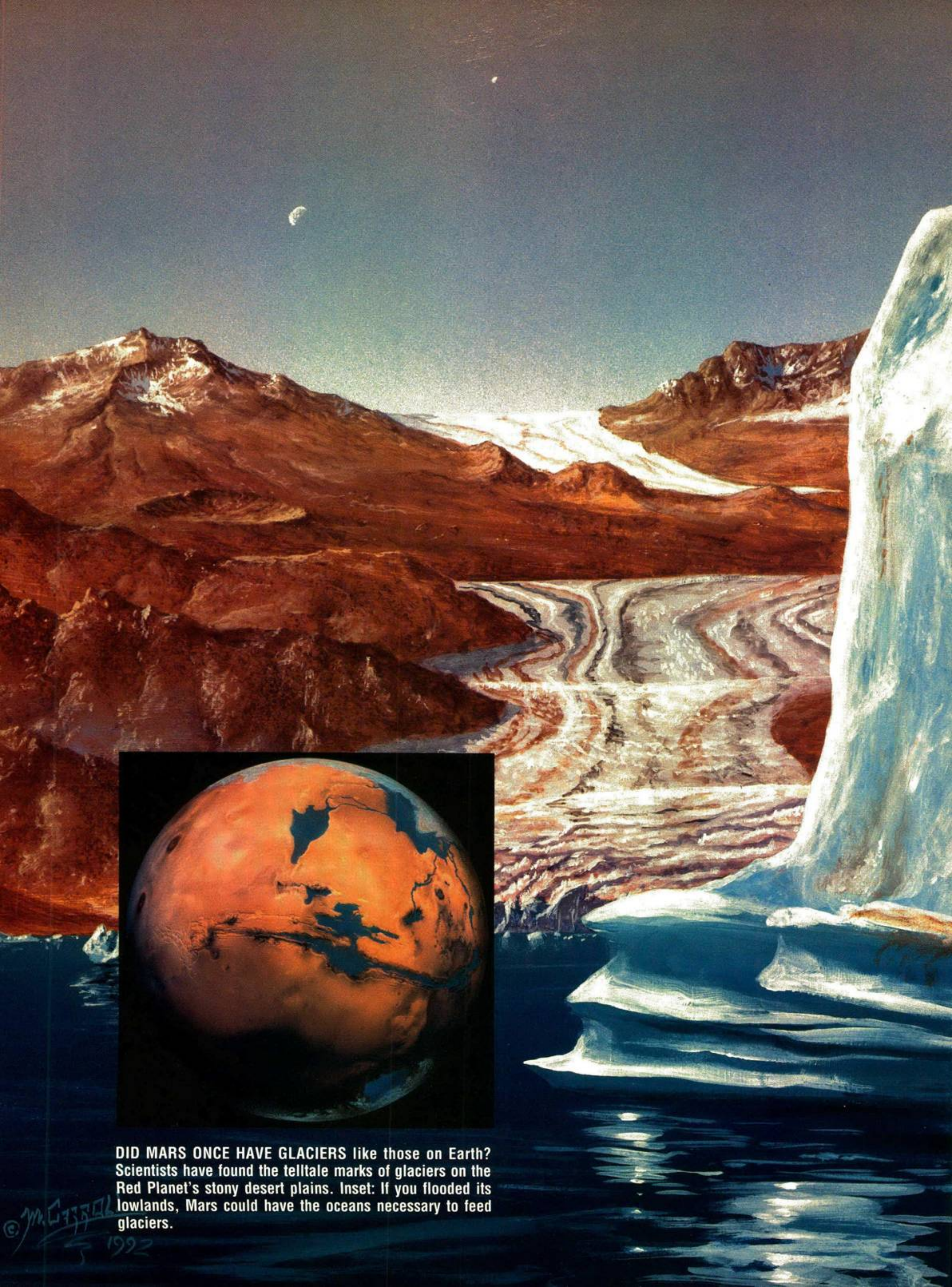
David Jewitt/University of Hawaii

THE DISCOVERY image shows 1992 QB1 as a tiny speck (arrow) among a cluttered starfield.

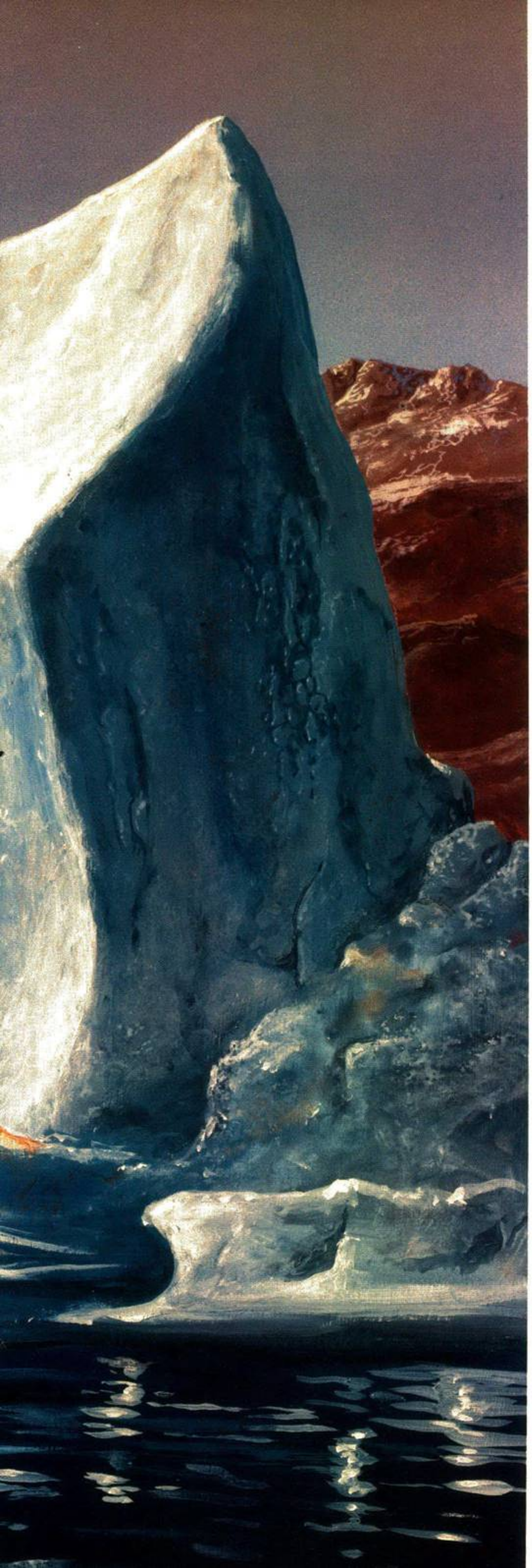
Some astronomers, however, are more cautious when interpreting 1992 QB1's significance. Richard P. Binzel of the Massachusetts Institute of Technology feels that astronomers need more data before making sweeping conclusions about a new class of objects in the solar system.

"1992 QB1 represents a class of large, primordial objects we are just beginning to discover," he says. "But it's premature to characterize that class in a rigorous way. The primary question is how many of these things are there?" Binzel believes a great deal of research will focus on this question. "I think we'll begin to wrestle with this over the coming years, but I'm not now ready to claim the existence of a Kuiper Belt. On the other hand, if in a decade we have several dozens of these objects, that will certainly be a reasonable conclusion."

The discoverers themselves are quietly confident. Says Luu: "Many people didn't expect us to find anything. Hopefully this will excite people and get them going on some new research." Perhaps the find will also help to confirm a new picture of the solar system as well. □



DID MARS ONCE HAVE GLACIERS like those on Earth? Scientists have found the telltale marks of glaciers on the Red Planet's stony desert plains. Inset: If you flooded its lowlands, Mars could have the oceans necessary to feed glaciers.



Michael Carroll

THE ICE AGES OF MARS

Glacial scars on the Martian surface point to an Earth-like planet with moving ice sheets and warm, wet weather.

by Jeffrey S. Kargel and Robert G. Strom

Mars is a cold, dry, barren world. It's hardly a place astronomers associate with life, let alone balmy temperatures and vast oceans of water. When the Viking spacecraft landed on Mars in 1976, they found no sign of fertility. The old science fiction dictums that Little Green Men roam the planet's surface, fueled by Percival Lowell's observations of "canals," were proven to be the creations of human minds with no basis in reality. And just as clearly, the probes showed that Mars is nothing like Earth.

That's the conventional view. But the Mars we know today may have been very different in the ancient past. Astronomers studying the images made by the Viking orbiters are finding evidence of ancient glaciers on Mars — massive ice sheets that slid across the planet's surface and left telltale scars on the terrain. These ice sheets may have been similar to those that covered much of Earth in the Pleistocene Ice Age and that now cover Antarctica.

The existence of large ice sheets in Mars' past suggests the planet once had a denser atmosphere and large bodies of water comparable to oceans on Earth. These would have been necessary to supply the amount of snowfall needed to grow glaciers. If Mars did go through a warm, wet period, then it might have offered the right kind of atmosphere for the formation of life. Simple life-forms may have established a foothold on the Red Planet for a brief time before being extinguished by an increasingly unlivable environment. If this is true, such life on Mars may yet be detectable, perhaps in the form of microfossils.

Mars As We Know It Today

Before examining the evidence for Martian glaciers, we need to understand how Mars works today. Its atmosphere is very cold and thin, having about 1/100 that of Earth's atmospheric surface pressure, and it consists of about 95 percent carbon dioxide with a trace of water vapor. Mars, like Earth, currently has perennially stable ice caps and seasonal snow and cloud cover at high latitudes. Martian snow and frost, composed mainly of carbon dioxide, accumulates each winter on each hemisphere to an average depth of five feet down to about 45° north and south latitudes, but in most areas the snow is completely gone by summertime.

The permanent Martian polar ice caps are at least thousands of feet thick in places, but cover small areas relative to the great ice sheets in Greenland and

Antarctica. Mars' bright, dust-free ice caps are surrounded by much wider and thicker layered deposits thought to be composed of interleaved ices and dust. Mars' northern ice cap is composed of water ice, whereas the southern cap contains in part frozen carbon dioxide.

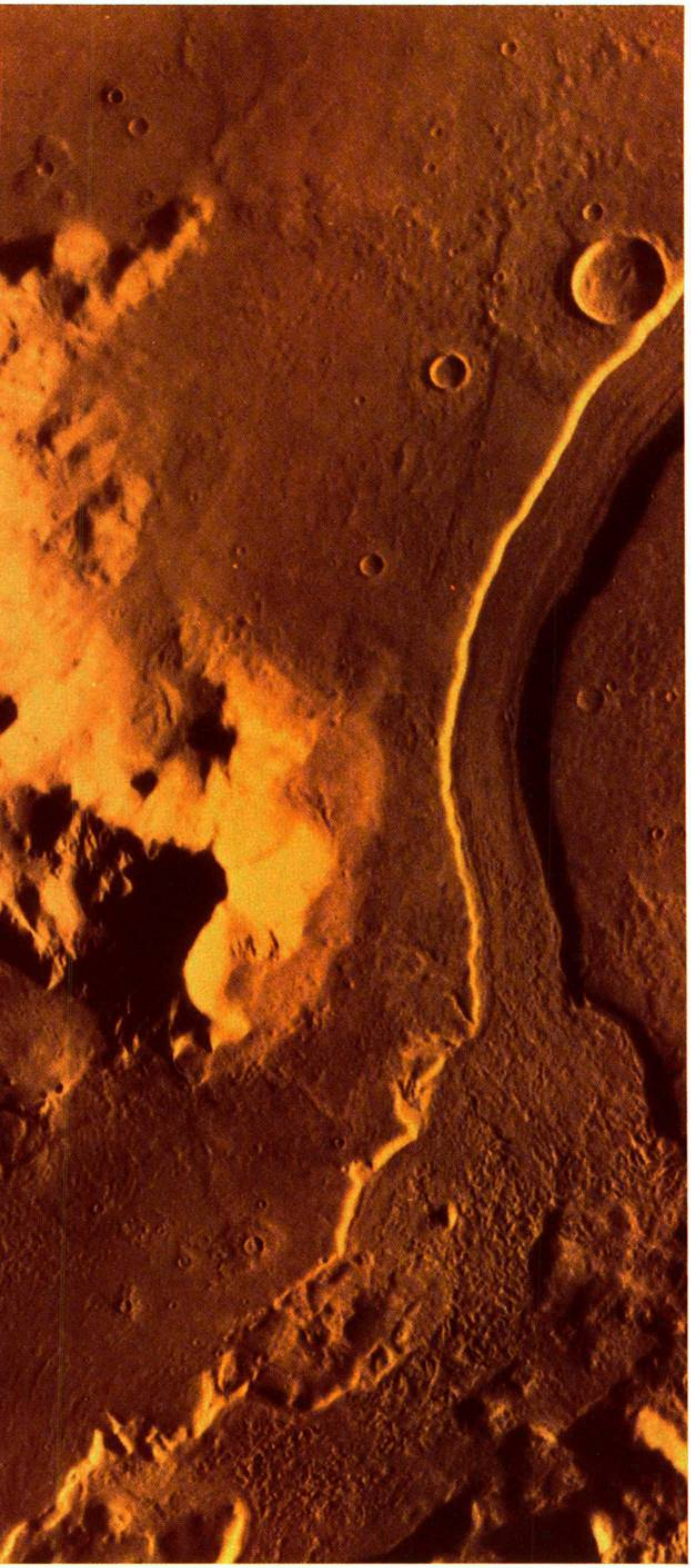
Planetary scientists can't be sure that these ice caps act like glaciers. Glaciers are moving ice sheets that act upon the surface below them like giant conveyor belts, dredging and depositing rock and gravel and creating a variety of surface features. As the ice sheets grind across a planet's surface, they create moraines: large ridges marking pauses or endpoints in the glaciers' movements. They also form eskers: smaller, narrower, winding ridges of sand and gravel deposited by rivers of meltwater flowing inside the glacier. Hills are shaped by the glaciers' motion, and meltwater can fill depressions in front of the glaciers as lakes. Numerous glacial features like these are visible on Earth and some are also visible on Mars.

Ages of Rocks

Before examining the evidence for moving ice and water on the surface of Mars, it's essential to put Martian geology into perspective so we can begin to establish when certain events like glaciation occurred. The geologic history of Mars divides into three major time periods. The oldest era is the Noachian period, which roughly coincides with the period of heavy solar system bombardment, a period that ceased about 3.5 billion years ago. Apparently, during this time much of the Martian crust formed and some of the planet's largest terrain features developed. The middle era is the Hesperian period, from about 3.5 billion years ago to perhaps 2.7 billion years ago. This is when many of the large flood channels formed and widespread outpourings of lava occurred. The youngest era, the Amazonian period, began about 2.7 billion years ago and witnessed volcanic activity in the planet's Tharsis region, the erosion of young outflow channels, and the basic establishment of Mars' present appearance.

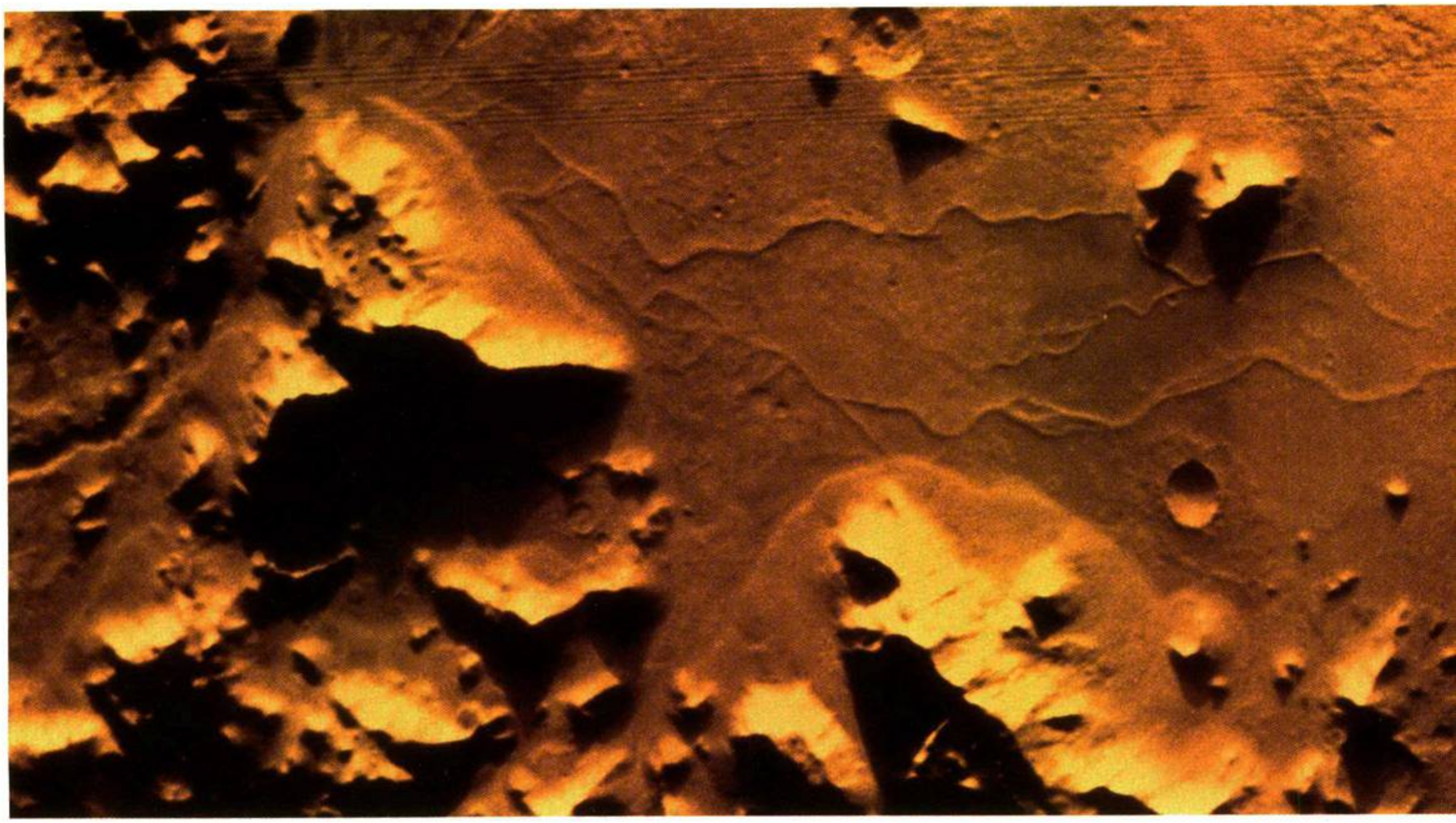
Planetary scientists use the number of impact craters visible on various landforms to date them. This is possible because they have a pretty good idea of the rate of cratering at different times in solar system history. To date a glacial event, they determine the number of impacts that clearly appeared after the glacial activity stopped. Craters with diameters smaller than about one kilometer provide the best results because they are destroyed relatively easily by glacial processes. Therefore, the number of small craters per unit area formed after glaciation stopped gives a good technique for dating.

By counting craters, planetary scientists have found that two major eras of glacial activity occurred on Mars. The youngest took place relatively recently in Martian history, during a time called the Little Ice Age. A separate, far more significant era of glaciation took place before the Little Ice Age. The problem is that extrapolating the dates from crater counts becomes quite uncertain as we go back by hundreds of millions or billions of years. Planetary scientists know that this major glacial period, the Big Ice Age, took place well after the period of heavy bombardment stopped about 3.5 billion years ago. The rough window for this ice age is probably anywhere from 2 billion years ago to some 300 million years ago. The Little Ice Age occurred between 300 million years ago and the present and characterizes the present-day Martian climate.



All photos courtesy NASA

GLACIERLIKE FLOWS on Mars formed during the "Little Ice Age," sometime in the last 300 million years. This channel, 800 feet deep, once carried a glacier from the Hellas Montes.



ICE EROSION, GLACIAL DEPOSITS, AND ESKERS are visible in the Argyre Basin. Glaciers carved the peaks and deposited the long, winding eskers visible near the top of the image.

One of the most startling aspects of Martian glaciation is the relative youth of the ice ages. Planetary scientists have always thought that the most intense episodes of water and ice activity on Mars happened long ago, when the solar system was young. If the glacial hypothesis is proven correct, both the magnitude of activity and its timing will require radical revisions in our history of water on Mars.

Find the Glacial Scars

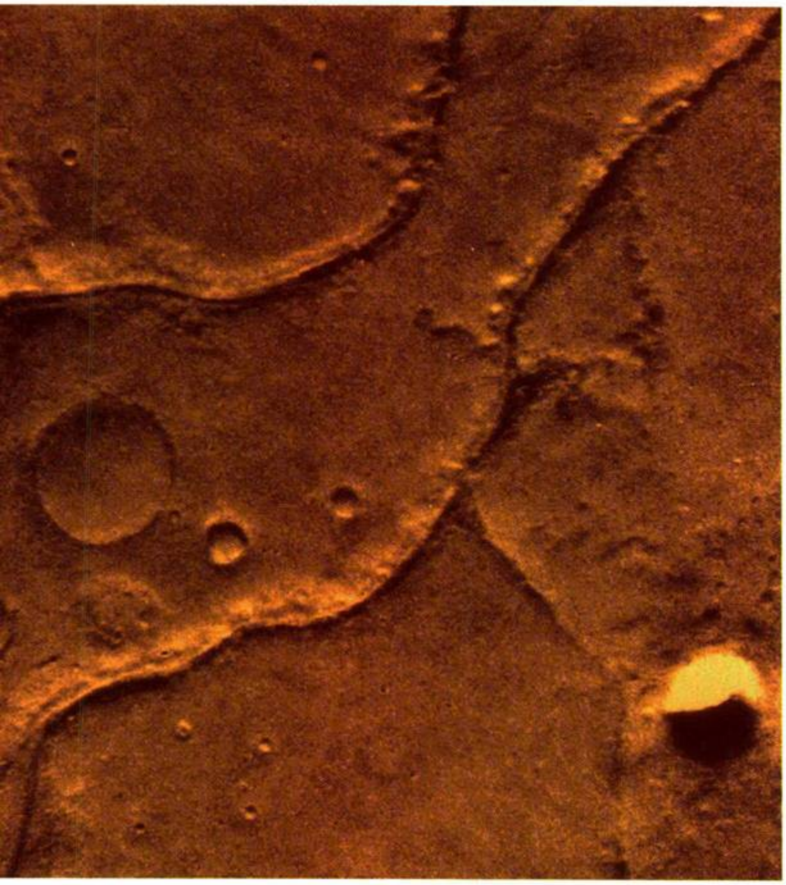
The evidence for glacial features in both Martian ice ages is compelling. In the Viking image on the opposite page you can see two spectacular examples of Little Ice Age features formed by flows of glaciers dragged along the Martian surface by gravity. One flow has moved, glacier style, down the steep slopes of a mountain towering 8,000 feet above the adjacent plains. The other feature occurs in the channel which formed on a gently sloping gradient. Although planetary scientists do not yet know exactly what flowed into the channel, it seems that it was something like a dirty ice glacier. Scientists don't know whether enough ice still exists in these Martian channels to cause a glacier-style creep over millions of years. But an absence of impact craters in these features means they have to be relatively young. It places them solidly in the Little Ice Age.

In this mountainous area in Mars' southern hemisphere, glacial scars blanket the slopes of major peaks that face the south pole. The extremely high southern sides of these mountains are scalloped much like the glacial peaks in the Swiss Alps and Canadian Rockies. But the Martian landscape varies wildly over short distances. In a stark contrast of erosional styles, the northern slopes of these same mountains, warmer because they face the planet's equator, display little glacial-type activity. Instead, northern slopes are typically gullied, possibly by meltwater streams produced as mountain snows melted during the Martian summers. These streams have been dry for a long time. However, relatively small changes in the planet's temperature and atmospheric density could have heated snow in the relatively recent past, causing it to flow as a liquid. This would be especially likely if sitting snow were covered by dust blown across the surface of Mars, raising the snow's temperature slightly.

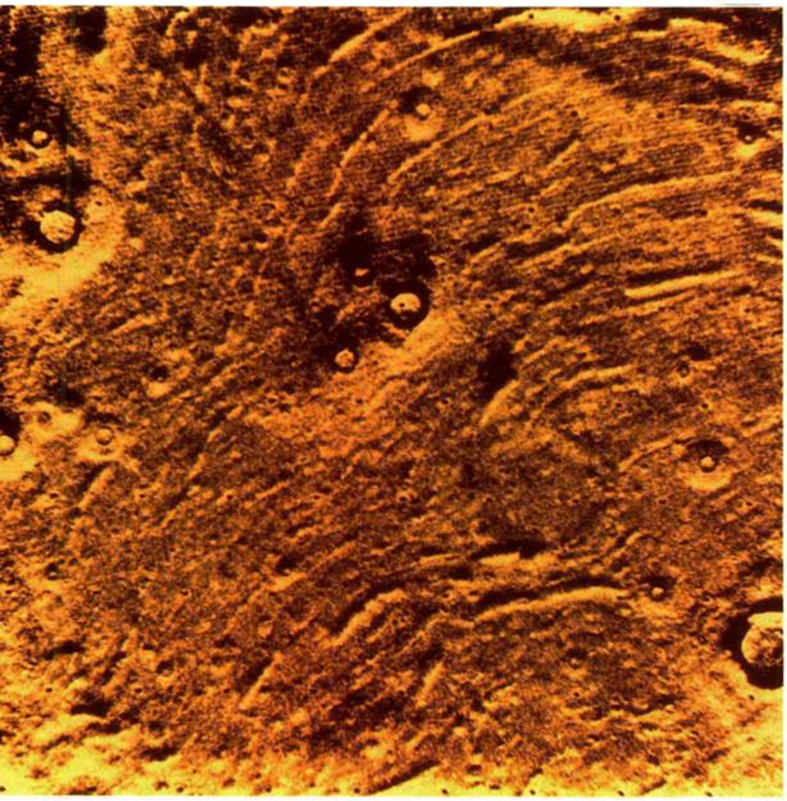
The Big Icing

As intriguing as they are, the landforms of the Little Ice Age represent comparatively small scale glaciation. But evidence of glaciation long ago, in the Big Ice Age, suggests that vast continental ice sheets slowly ground their way over the Martian landscape. Even more surprising, the evidence of ancient glaciation suggests the long-ago presence of a relatively warm, humid climate on Mars and a denser atmosphere than the one that now exists.

Like Earth landscapes, the ground on Mars exhibits a variety of glacial features in close, logical associations. In the images above and on the next page, you can see a variety of features related to the Big Ice Age associated with a giant impact feature called the Argyre basin. Argyre measures 1,200 kilometers across and contains sharp peaks in the southern part of the mountains that ring the basin. These mountains are equivalent to the Rook Mountains in the Orientale Basin on the Moon, which can be seen with a small telescope. Unlike the Rook Mountains, however, Argyre's rugged peaks apparently have been strongly modified by glacial ice,



ARGYRE'S ESKERS are ridges formed by sand and gravel that accumulated along subglacial rivers. Eskers are common glacial features on Earth and strongly resemble these ridges.



THUMBPRINT RIDGES in the Martian northern plains formed as a melting glacier retreated, dragging sediment and creating parallel sets of ridges.

resulting in the characteristic sharp relief commonly produced by alpine glaciation. Detailed views of these mountains show many parallels with terrestrial glaciated mountains. Glaciers apparently accumulated in the mountains and flowed down onto the floor of Argyre, carrying sediment produced by the erosion of the mountains.

The landforms on Argyre's floor suggest that when the large ice sheets eventually melted, they did so quite rapidly. Among many features in the image at left you'll see a set of sinuous, braided ridges. These are eskers much like those that formed in numerous areas on Earth. The final melting of the ice sheets in Argyre apparently produced a lake in which smooth sedimentary plains were deposited around the eskers. Other glacial features are widespread in both the northern and southern hemispheres of Mars, suggesting that in the Big Ice Age huge ice sheets covered the mid and high latitudes in both hemispheres.

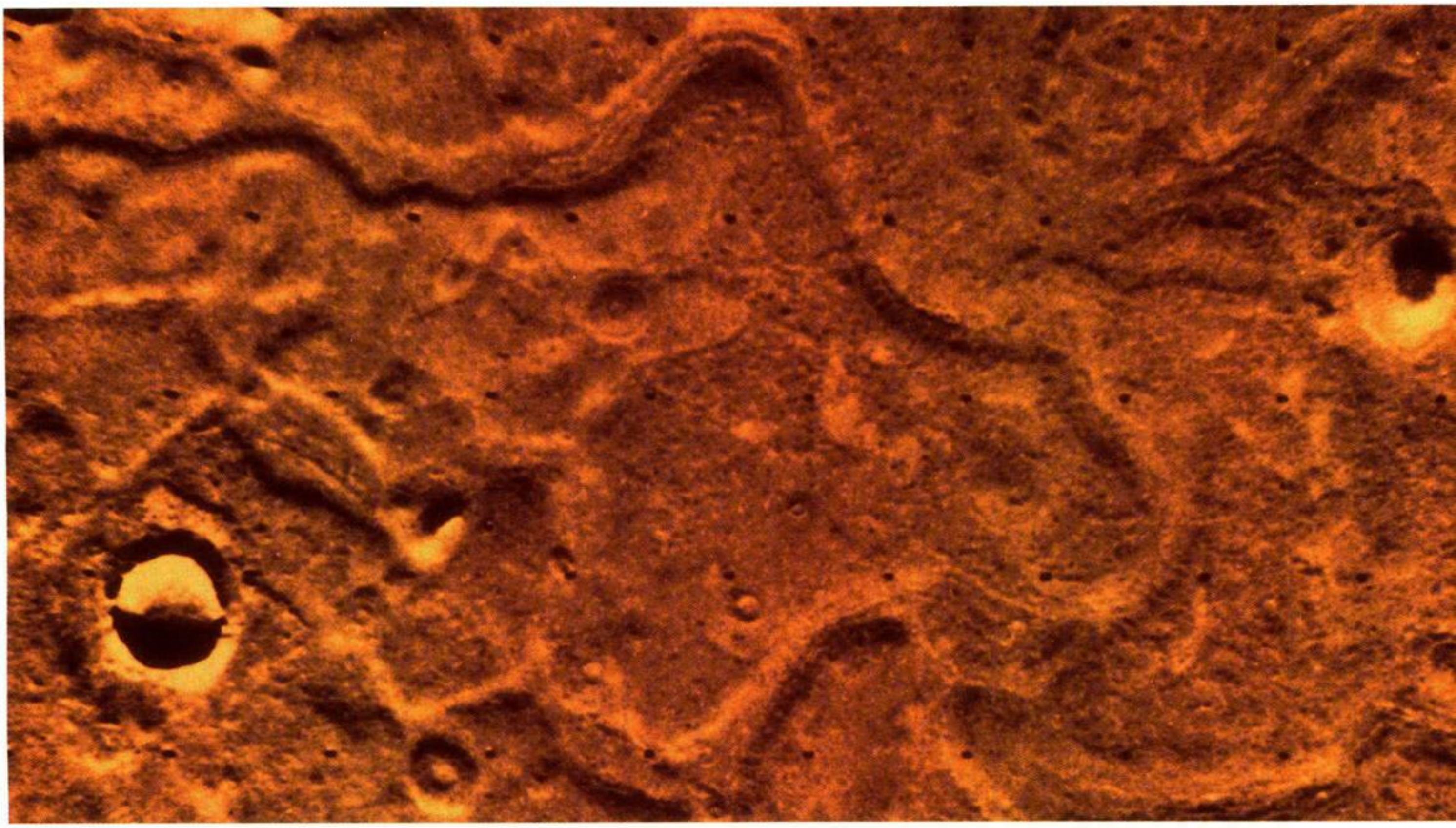
A similar type of feature occurs in the Martian northern plains and is visible in the images below left and opposite. The image on the opposite page shows a complex system of sinuous channels, many with channel-floor ridges. The pattern in these channels resembles the so-called tunnel channels on Earth, a type of erosional feature caused by floods of meltwater below the glaciers. An explanation for similar terrains on Earth is that a subglacial flood first eroded the channels into subglacial rock; then as the flood waters waned and pressures dropped, the ice walls and roof of the glacial tunnel closed in under the great weight of the ice above. Sediments deposited within the tunnel, producing the winding, narrow eskers on the floors of wider tunnel channels.

Immediately adjacent to this channeled terrain lies a set of evenly spaced ridges known by Mars specialists as "thumbprint terrain." These closely resemble features on Earth called De Geer moraines, thumbprintlike sets of ridges produced by deposits of glacial sediment near the base of an ice sheet. The similarity between these features on Mars and those long known to exist on Earth is striking.

Exactly how these thumbprintlike features are produced is a mystery, but it may go something like this: An ice sheet once flowed eastward and extended at least as far as the contact between the channeled terrain and the smooth plains. At some critical point the leading edge of the ice sheet collapsed as a gush of meltwater, long stored within the glacier, rushed forward. This formed the channels and deposited channel-floor eskers, probably over periods of only days. The leading edge of the ice sheet then retreated to the area of the thumbprint terrain, where a slower, more controlled retreat continued, generating the thumbprint ridges. Scientists have also proposed another explanation: Sediments are squeezed by the glacier into crevasses on the bottom of the ice sheet.

Let It Snow, Let It Snow, Let It Snow

The advance and retreat of ice sheets during the Big Ice Age implies a Martian climate radically different from the one that exists today. Advancing ice sheets require a steady supply of snow during winter that accumulates faster than it can melt the following summer. The snowfall need not be tremendous as long as some of it survives the summer. Martian ice sheets could have formed with less precipitation than



TUNNEL CHANNELS formed under great ice sheets as a flood of meltwater carved into the rock. As the floodwaters waned, deposits built up along the channel floors and created eskers within wide channels.

falls in the ice-free areas of Antarctica today, the so-called dry valleys, as long as temperatures were colder than they are in Antarctica. On the other hand, melting ice sheets require rather temperate conditions so ice melts faster than it accumulates. Most of the glacial landforms from the Big Ice Age resulted from melting ice. This, in turn, requires either a relatively warm atmosphere or ice melted by geothermal heat from inside the planet.

The existence of the ice sheets in the Big Ice Age means that Mars must have had a substantial reservoir of water and some way of cycling it through the atmosphere. The source of the ice sheets may have been large bodies of water in the northern plains. Recent evidence for such bodies of water, perhaps of oceanic dimensions, suggests that they formed from outflows that carved the largest channels on Mars. Furthermore, the age of these channels are late Hesperian through middle Amazonian, in fair agreement with the era of the Big Ice Age. Water in these northern seas or lakes would have evaporated into the Martian atmosphere and returned to the surface in the form of snow.

Is Anyone Home?

The most profound implication of the presence of ancient ice sheets and large bodies of water on Mars is the possibility that life once existed on Mars. Our understanding of how life begins seems to require the presence of liquid water. Current evidence strongly suggests that liquid water once existed on Mars. Based on the knowledge of how water behaves on Earth, scientists estimate that Mars may have had an Indian Summer, a warm, wet period that may have lasted for as long as one million years. Planetary scientists do not yet know when this occurred. Biochemists believe that the formation of life from complex organic molecules probably takes something like 2 to 5 million years, perhaps less. If liquid water remained on Mars for this period of time, could primitive life have formed in the warm pools on the ruddy surface of Mars? If primitive life did form, it probably didn't last long, dying out under the hostile conditions to come. But unlike Earth, where the earliest sediments have been destroyed or severely altered by plate tectonics and other geologic processes, the relatively unaltered early sediments of Mars may offer a unique opportunity to discover microfossil evidence of the earliest, primordial life forms.

Whatever the hope of finding Martian life, however, planetary scientists are enthusiastic about the unconventional and startling new view of Martian history that the glaciers offer. However, the glacial hypothesis raises some unanswered questions. Why has the Martian climate changed so drastically over the last billion or two years? Where did the Martian water that once was so plentiful go? Teams of planetary scientists are currently working on these and other questions, hoping to piece together a more accurate view of the mysterious Red Planet. With the arrival of the Mars Observer spacecraft in 1993, we expect to add large amounts of data on the question of Martian glaciers, gaining a clearer picture of a planet that has mesmerized humans for centuries. ☐

Jeffrey S. Kargel is a planetary scientist at the U.S. Geological Survey in Flagstaff, Arizona. Robert G. Strom is a planetary scientist at the Lunar and Planetary Laboratory of the University of Arizona in Tucson.

Giving Birth to Supernovae

Some nearby stars such as Betelgeuse may explode in the next few thousand years, creating the most spectacular supernovae ever witnessed.

by Andrew M. Thorpe

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EXPLODING STARS such as supernova 1987A, which occurred in the Large Magellanic Cloud, tell astronomers about the synthesis of elements in the universe.

Exploding stars in other galaxies dramatically display stellar evolution in progress. The explosions, called supernovae, scatter gas and dust into the galaxy that later become the ingredients for new stars. Each successive generation of supernovae slowly builds the heavier and heavier elements, including those elements crucial to life as we know it.

Observing the bright outburst of light from nearby — and even distant — supernovae is relatively easy. But how does one detect a supernova before it explodes? Unfortunately astronomers can't predict when a star will explode, but they can predict which stars most likely will explode in the future. To identify these supernovae progenitors, researchers first looked at the types of stars that have exploded in the past.

Astronomers classify supernovae into four basic types: Ia, Ib, Ic, and II. A type Ia supernova originates in a close binary system when a star dumps mass upon its white dwarf companion, causing it to explode. A type Ib, Ic, or II supernova starts as a very massive star that collapses under its own weight once the nuclear fuel in the star's core runs out. The collapse of the star's core triggers the explosion of the star's outer layers into space. The spectra of types Ib, Ic, and II look similar except that Ib and Ic spectra lack strong hydrogen lines. Presumably, a companion star stripped away the progenitor star's hydrogen atmosphere before collapse.

So to identify supernovae progenitors, astronomers look for white dwarfs in close binary systems and for very massive stars. In both cases, such stars exist in our neighborhood of the Milky Way Galaxy. Some of these supernova progenitors are familiar to most backyard observers.

Betelgeuse and Red Supergiants

The most familiar example of a supernova progenitor is Betelgeuse, the bright red supergiant marking Orion's right shoulder. Located at a distance of about 650 light-years from Earth, this star is in the twilight of its life cycle. Different layers in the core fuse helium into carbon, turn helium and carbon into oxygen, and produce magnesium from carbon. Eventually, these processes will form silicon and iron. But then the fusion of elements will stop because, unlike all of the previous fusion steps, iron requires more energy to fuse than it releases. The stoppage of energy will cause Betelgeuse's core to collapse, triggering a supernova explosion. This explosion most likely will occur sometime during the next few thousand years because the supergiant phase of massive stars doesn't last very long.

Exactly when the explosion will occur depends in part upon the pulsations of Betelgeuse's surface. These pulsations currently give rise to changes in the star's brightness by up to a factor of 2, or almost one magnitude. The throbbing of the star's surface also mixes material from deep in the star with the hydrogen-rich material at the surface. The mixing can speed up or slow down the reactions in the interior. Also, the pulsations eject some of the surface material from the star into space. The loss of mass can cool the interior of the star, slowing the nuclear reactions inside.

Astronomers can't say yet whether Betelgeuse may eject enough matter to reduce or eliminate its chances of going supernova. At its present expenditure of over one trillion tons of material per second, much of the star's outer envelope will vanish into space. Without enough mass in the envelope to maintain its pressure on the core, Betelgeuse may suffer only a mild explosion, leaving behind a planetary nebula. The core would become a lowly white dwarf instead of the neutron star that a supernova would create. But if the mass loss rate slows and does not deplete the star's outer envelope by the end of Betelgeuse's supergiant phase, the core could still collapse, producing a spectacular supernova that would outshine the Full Moon in our skies.

Jim Baumgardt

MASSIVE RED SUPERGIANTS such as Betelgeuse (the reddish star at Orion's right shoulder) are prime candidates for future type II supernovae.

Another factor makes scientists uncertain about Betelgeuse's future: a nearby companion star. The inner member of the system is so close to Betelgeuse that it actually orbits *within* the supergiant's atmosphere. During the remainder of Betelgeuse's lifetime, the gravity of the inner star may sweep up matter, further depleting the supergiant's hydrogen envelope. This companion could end up robbing Betelgeuse of the necessary mass needed for core collapse.

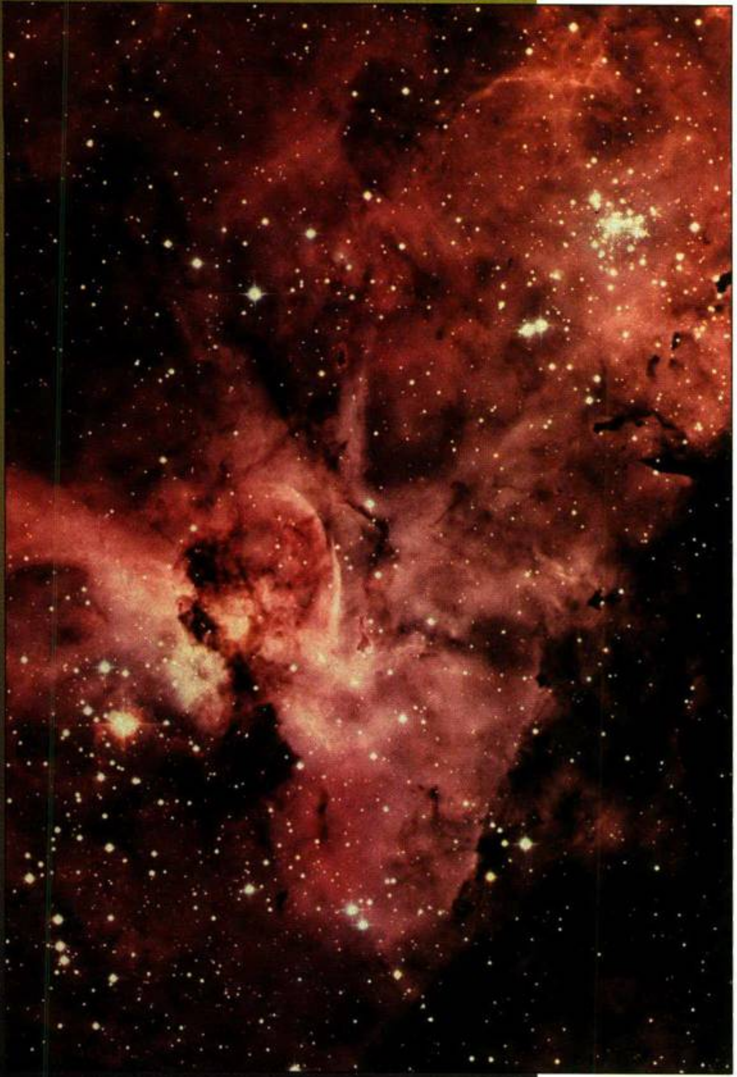
Using Betelgeuse as a standard, astronomers can derive criteria for other supernova progenitor candidates. Observations show that a progenitor loses mass and varies in brightness because of pulsations in the star's atmosphere. Pulsations dredge up elements from deep in the interior, so the outer envelope in the later stages contains heavy elements such as potassium, magnesium, and silicon. When the star creates these heavy elements, churns them up from the lower layers, and eventually ejects them into space, the supergiant is nearing its spectacular death.

These convulsions exist in other notable supergiants that may soon collapse into white dwarfs or neutron stars. Examples are Mira (Omicron Ceti), Ras Algethi (Alpha Herculis), Antares (Alpha Scorpii), and Mu Cephei (also called the Garnet Star). These stars are located within a few thousand light-years of Earth, undergo pulsations and mass loss, and exhibit brightness variations. Mira also shows signs of heavy elements in its outer envelope. These stars are all prime candidates for possible supernovae explosions in the next few thousand years.

Finding other red-supergiant progenitor candidates may be more difficult. These stars lie in the spiral arms of our Galaxy near the gas and dust clouds from which they formed. These same gas and dust clouds shield the stars from our view. But our search for progenitors has only started.

Blue Supergiants, Too

Though red supergiants are the most likely candidates to become type II supernovae, astronomers have recognized recently that some blue supergiants may go supernova. Supernova (SN) 1987A in the Large Magellanic Cloud resulted from the explosion of Sanduleak −69°202, a blue supergiant about 25 times the Sun's diameter. (Red supergiants are about 500 times the Sun's diameter.) Unlike supernovae from the explosions of red supergiants, SN 1987A did not appear as bright as expected.



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THE BLUE SUPERGIANT Eta Carinae may explode in the next 10,000 years, creating the greatest supernova ever observed.

According to Kris Davidson of the University of Minnesota, "A red supergiant doesn't have to expand very much and it doesn't lose much energy before it becomes a supernova. But SN 1987A was a blue supergiant. By the time we saw it as a supernova, it had to expand a lot, wasting a lot of energy."

During the final stages of Sanduleak –69°202's life, the energy that normally would have made the explosion shine brightly went instead into the expansion of the gas, dampening the optical display. Astronomers are still debating the reasons, but the progenitor may have lacked the necessary elements, such as oxygen, required to create a stable red supergiant stage. Instead the star became a dense, blue supergiant. Its compactness tempered the brightness of the supernova's outburst.

Astronomers are watching other blue supergiants that may one day become supernovae. One candidate is Eta Carinae, the bright southern star located 9,000 light-years away in the vast gaseous cloud that bears its name. This star's brightness has varied dramatically over the last century and a half. In the 1830s and '40s, observers witnessed this supergiant rise from 4th magnitude to magnitude –1, making it the second-brightest star in the sky. Over the decades it faded slowly to 8th magnitude, but it is now back up to magnitude 5.8.

Astronomers now believe that the observed brightening was really a small explosion that engulfed the star in a nitrogen-rich cloud. Apparently, Eta Carinae is showing the symptoms of imminent disaster. Davidson says that Eta Carinae is now nearing its final stage as a supergiant and suspects that a supernova might occur within the next 10,000 years. With a mass that is 80 to 100 times that of the Sun, it may become the greatest supernova ever witnessed by human observers.

"It probably is about to become a Wolf-Rayet star," says Davidson. Wolf-Rayet stars are hot, massive stars that undergo intense mass loss. The large amount of nitrogen in their spectra shows that they have already become supergiants once — perhaps even red supergiants if massive enough. The large mass loss removes the star's outer layers, stopping the supergiant phase and turning it into a Wolf-Rayet star. "This kind of star can no longer be a red supergiant, so it becomes a Wolf-Rayet star before it goes supernova."

Eta Carinae's large mass, high rate of mass loss, and shell containing heavy elements meet the criteria for a supernova progenitor. Eta's mass promises a brilliant supernova display, easily outshining Venus at maximum light.

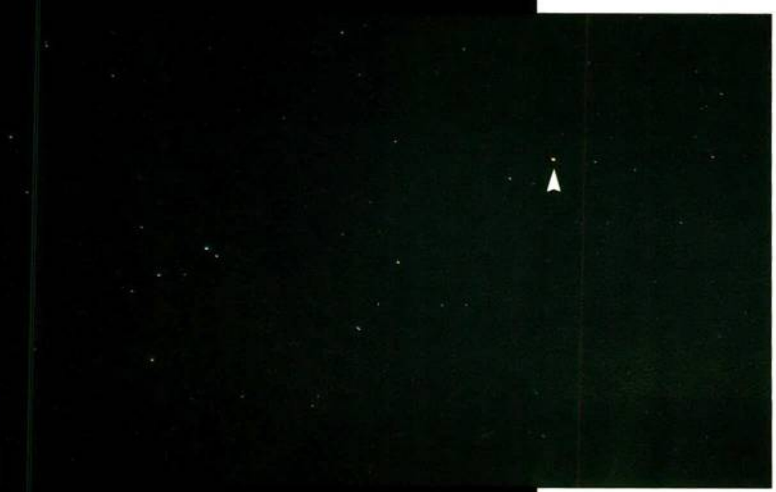
There are other Wolf-Rayet stars that are good candidates for type II supernovae progenitors. One is 11th-magnitude HD 56925 in the constellation Canis Major. The star is embedded in a bright nebula called NGC 2359. A second is HD 192163, which is a 7th-magnitude object in the Crescent Nebula (NGC 6888) in the constellation Cygnus.

Other Progenitors

Supernova progenitors are not always the most conspicuous stars in the Galaxy. In fact, type Ia progenitors may be beyond detectability. Type I systems normally are far less luminous than red and blue supergiants. Yet when they are at their critical phase, they can rival the light output of type IIs and even the brightness of their parent galaxies.

Type Ia supernovae occur in binary systems where one star loses mass — mostly hydrogen gas — to its white dwarf companion. Normally the accretion of hydrogen onto the white dwarf's surface sparks a small outburst when enough hydrogen accumulates to

RED SUPERGIANT Antares (arrow) appears bright at the heart of Scorpius and someday may become a type II supernova.



Steve Walther

start nuclear reactions. Astronomers observe these small outbursts as cataclysmic variables or novae. But in a type Ia supernova, the white dwarf receives too much mass from its companion. A typical white dwarf has 0.6 times the Sun's mass. The star can remain stable if its mass remains below the Chandrasekhar limit of 1.4 times the Sun's. Unfortunately, in a type Ia system the white dwarf accumulates more mass than this.

Instead of starting nuclear reactions at the star's surface, the gas causes the star to catastrophically collapse, forming a neutron star. Nuclear reactions start in the collapsing star's core. This sudden burst of energy causes the star to explode, annihilating itself.

An example of this process may be found in the constellation Scorpius. Astronomers have discovered what appears to be a type Ia progenitor approaching critical mass. U Scorpii is a variable star located about 8 degrees north of Antares near the Scorpius-Ophiuchus border. Astronomers first noticed this 17th-magnitude star in 1863 when an eruption brightened it. Since then it has brightened spontaneously up to 8th magnitude at least four more times. It is presently labeled as a recurrent nova that researchers believe is rapidly accreting matter from its companion.

Sumner Starrfield of Arizona State University believes that U Scorpii is reaching critical mass and should go supernova during the next 100,000 years. "Most of the material that is accreting from the secondary remains on the white dwarf. The mass is almost at the Chandrasekhar limit. It may take no time at all to drive it over."

Most cataclysmic variables and novae will not become type Ia supernovae. But Starrfield says the best candidates are recurrent novae. These stars may have accumulated enough mass such that they are near the Chandrasekhar limit. Finding these systems though is tough.

"Type Ia systems are often very faint," says Marshall McCall of York Observatory in Toronto. "It could well be that a system lies nearby and is just too hard to see."

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HOT, MASSIVE EVOLVED STARS that have lost their outer layers through mass loss may go supernova when their cores run out of nuclear fuels. The Wolf-Rayet star HD 56925 in NGC 2359 is one such star.

Which Star is Next?

By astronomers' calculations, a supernova should occur in our Galaxy every 30 years on average. Many people believe this means a supernova near our solar system is long overdue. But the key phrase is "on average." Supernovae don't appear like clockwork. And there is a good chance that the next supernova will appear in a part of the Galaxy that astronomers can't observe.

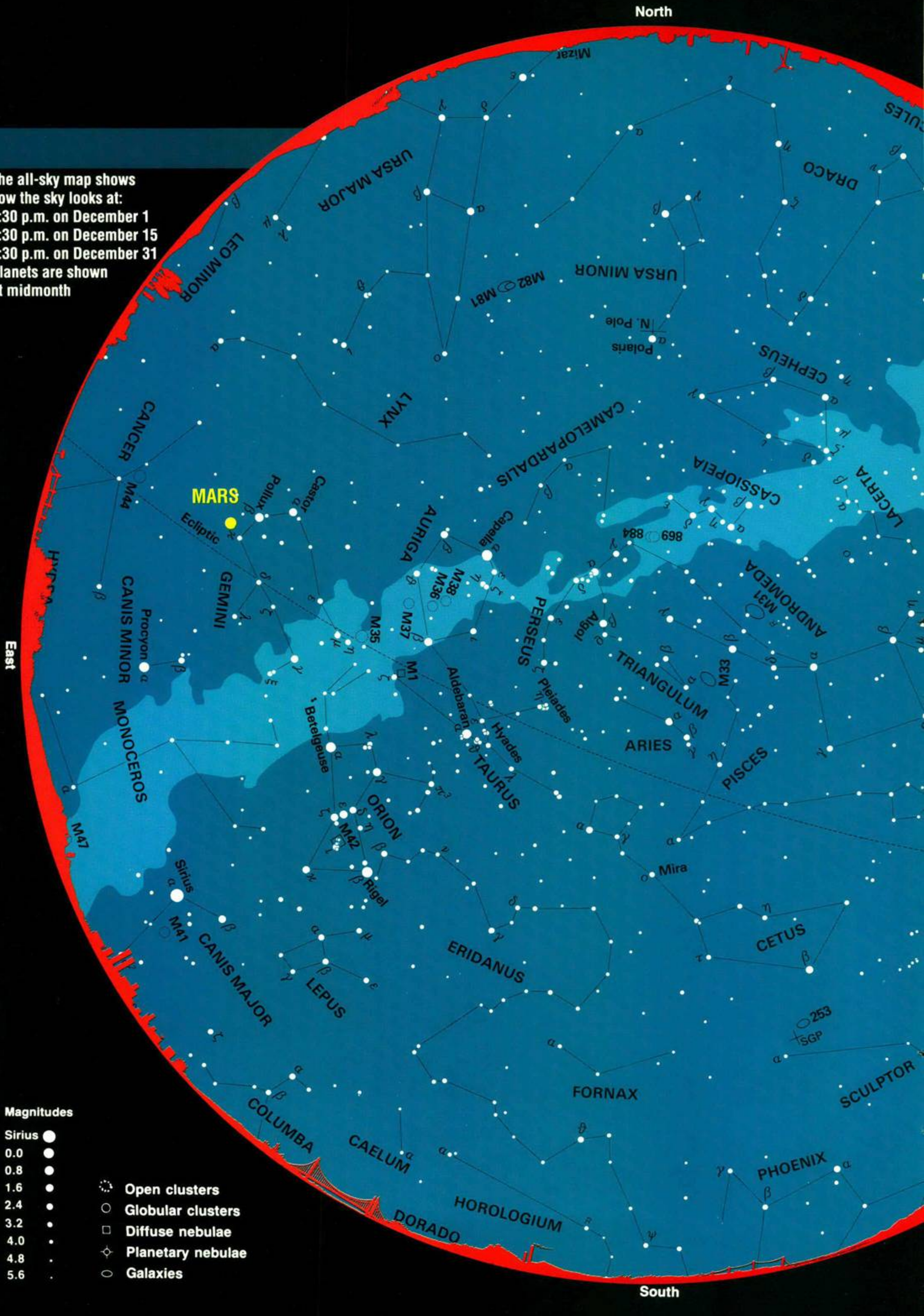
Years ago some supernovae, such as Cassiopeia A, exploded without detection. Dust shielded the outburst from optical visibility 300 years ago. But modern radio and infrared observations will help prevent future supernovae from passing undetected.

Although researchers now have a better idea of which stars may end their life cycles in a supernova explosion, predicting whether a particular star will go supernova, much less when, remains difficult. The best candidate for a progenitor, Betelgeuse, has enough variables — mass loss, effects of companion stars, and internal mixing — that a clear prediction whether Betelgeuse will become a supernova still isn't possible.

So for the near future, astronomers need to be vigilant and survey the skies for those stars that have just become supernovae. Each star leads to a better understanding of which stars go bang in the night and what stellar characteristics indicate that a star is ready to go supernova. From this information, supernova predictions will someday be feasible. Until then, keep looking up, because no one knows which star is next. □

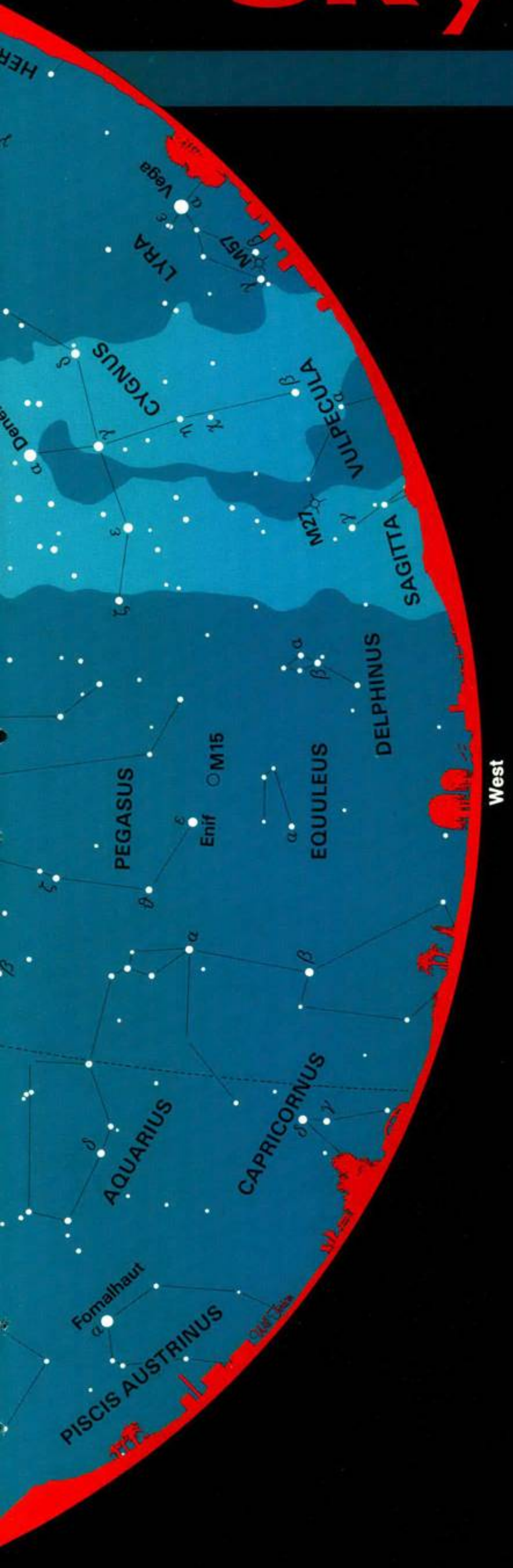
Andrew M. Thorpe wrote "Should You Keep an Astronomical Notebook?" for the January 1988 issue of A*STRONOMY.*

The all-sky map shows how the sky looks at:
9:30 p.m. on December 1
8:30 p.m. on December 15
7:30 p.m. on December 31
Planets are shown at midmonth


North
South
East
Mizar
CULES
DRACO
URSA MAJOR
LEO MINOR
URSA MINOR
M82
M81
N. Pole
Polaris
CEPHEUS
LYNX
CAMELOPARDALIS
CANCER
M44
MARS
Pollux
Castor
Ecliptic
CASSIOPEIA
LACERTA
AURIGA
Capella
884
869
HYDRA
CANIS MINOR
Procyon
GEMINI
M38
M36
M37
M35
M1
PERSEUS
Algol
ANDROMEDA
M31
TRIANGULUM
M33
Pleiades
Aldebaran
Hyades
TAURUS
ARIES
PISCES
Betelgeuse
MONOCEROS
ORION
M42
Rigel
M47
Sirius
M41
CANIS MAJOR
LEPUS
ERIDANUS
Mira
CETUS
253
SGP
FORNAX
SCULPTOR
COLUMBA
CAELUM
PHOENIX
HOROLOGIUM
DORADO
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

December 1992



LUNAR ECLIPSE ON DECEMBER 9

The first total lunar eclipse in nearly three years decorates the nighttime sky on December 9/10. Observers in eastern North and South America as well as those in Europe, Africa, and western Asia can enjoy the entire eclipse. People in the western half of the Americas will get a good view of the end of the eclipse, while those in eastern Asia will see the eclipse's beginning.

GEMINIDS PEAK ON DECEMBER 13

Though a nearly Full Moon hampers viewing of the Geminid meteor shower this year, you can still expect to see a few dozen meteors per hour during the shower's peak on the night of December 12/13.

SOLAR ECLIPSE ON DECEMBER 23

Two weeks after the total lunar eclipse, a partial solar eclipse can be seen from eastern Asia, the northern Pacific Ocean, and parts of Alaska. Maximum eclipse occurs in northern Siberia, where 84 percent of the Sun will be blocked by the Moon.

TOUTATIS PASSES NEAR EARTH

An asteroid that normally appears very faint makes an exceedingly close pass by Earth in December, brightening enough to be seen in backyard telescopes. Asteroid 4179 Toutatis comes within about 2.2 million miles of Earth — ten times the Moon's distance — and glows at magnitude 9.4 in mid-December.

Calendar of Events

1 The Moon is at apogee (251,290 miles from Earth), 3:10 p.m. EST
2 First Quarter Moon is at 1:17 a.m. EST
3 Asteroid Dembowska is at opposition
4 Vesta is in conjunction with the Sun
9 Mercury is at greatest western elongation (21°)
Full Moon is at 6:41 p.m. EST; total lunar eclipse
13 Asteroid Toutatis is at its brightest
Geminid meteor shower peaks
The Moon is at perigee (228,647 miles from Earth), 4:06 p.m. EST
16 Last Quarter Moon is at 2:13 p.m. EST
21 Winter solstice is at 9:43 a.m. EST
Venus passes 1.1° south of Saturn, 11 a.m. EST
22 The Moon passes 1.5° south of Mercury, 9 a.m. EST
Mars passes 3° south of Pollux, 4 p.m. EST
23 New Moon is at 7:43 p.m. EST; partial solar eclipse
27 Juno is at opposition
29 The Moon is at apogee (251,699 miles from Earth), 12:05 p.m. EST
31 First Quarter Moon is at 10:38 p.m. EST

Eye on the Sky

by Deborah Byrd

A PAIR OF ECLIPSES

Nearly everyone in North America can step outside on the evening of December 9 to see that some or all of the Moon's face is submerged in Earth's shadow. This is the first total lunar eclipse since February 1990. (For complete details on the eclipse, see "When the Moon Disappears" on page 70.)

Lunar eclipses are easy to see, but how much you see depends on your location. This eclipse takes place just after the Moon rises in the early evening hours for observers in northeastern North America, who are privileged to see it all. Farther west and south, the Moon rises after the eclipse has begun. Observers on the west coast see only the final partial phases in progress at moonrise. The Moon is expected to be quite dark during this eclipse, thanks to volcanic debris hurled into Earth's stratosphere during the June 1991 eruption of Mount Pinatubo in the Philippines.

Half a month after the lunar eclipse, on December 23/24, a partial solar eclipse greets observers in parts of Alaska and eastern Asia. A lunar eclipse takes place when Earth's shadow falls on the Moon, while a solar eclipse happens when the Moon passes in front of the Sun and casts its shadow earthward. At mideclipse, the Moon blocks 84 percent of the Sun from our view.

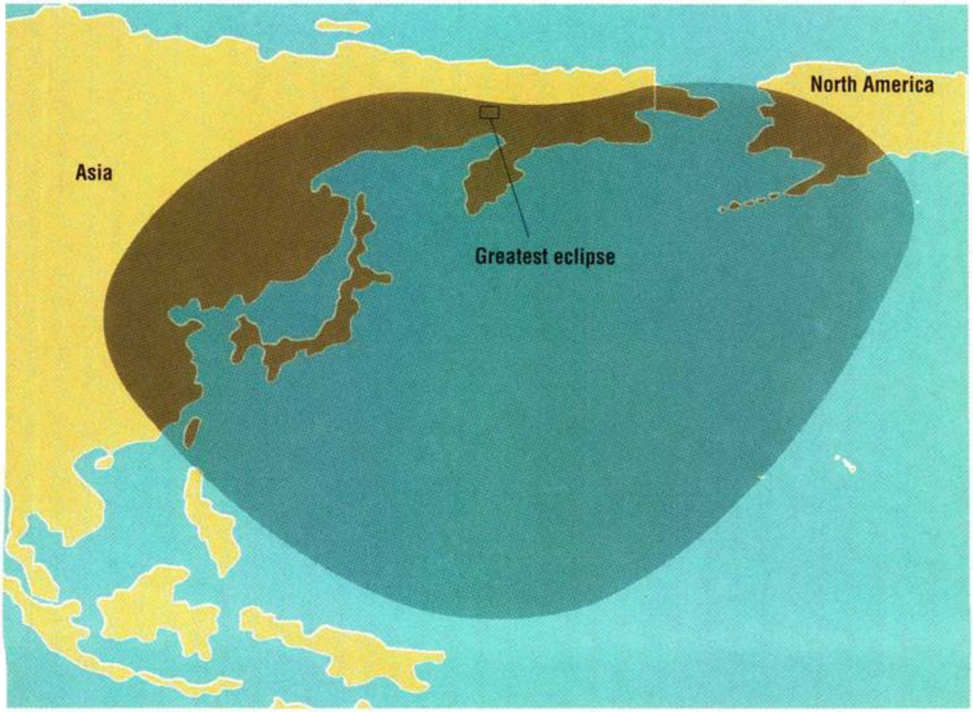
A HIGH-ALTITUDE FULL MOON

The Moon and Sun are joined together for yet another reason this month. At 9:43 a.m. EST on December 21, the Sun reaches its most southerly point on the imaginary celestial sphere surrounding Earth. Winter begins in the Northern Hemisphere and summer commences in the Southern Hemisphere. Every year the Full Moon nearest the solstice displays a special trait, one that's peculiar to the winter season. For centuries, perhaps millennia, people have noticed that December's Full Moon seems to shine more brightly than usual.

The cause stems from the path of the Moon across the sky. Around the time of the December solstice, when the Sun travels its lowest path as seen from the Northern Hemisphere, the Full Moon makes its highest arc across

Diego Meozzi

A PARTIAL SOLAR ECLIPSE greets observers in eastern Asia and parts of Alaska on December 23/24. Up to 84 percent of the Sun is blocked from view at greatest eclipse, reducing the already meager sunlight on this December day.



TIME AND PERCENT OF MAXIMUM ECLIPSE

City	Universal Time	Percent Eclipsed
Anchorage	0h43m	35%
Beijing	23h32m	41%
Guangzhou	23h05m	1%
Changchun	23h33m	57%
Hiroshima	23h26m	45%
Nanjing	23h14m	28%
Nome	0h40m	55%
Okhotsk	0h12m	82%
Osaka	23h31m	49%
Pusan	23h25m	44%
Shanghai	23h15m	29%
Shenyang	23h28m	52%
Seoul	23h26m	47%
Taipei	23h10m	15%
Tokyo	23h38m	54%
Unalaska	1h17m	66%
Vladivostok	23h37m	60%
Wuhan	23h17m	20%

the winter sky. This is simply because the Moon must be opposite the Sun to appear full to us. When the Sun is low in the sky around the time of the December solstice, the Full Moon must be high in the sky.

This month's Full Moon emerges from its total eclipse in a triumph of bright moonlight over the darkness of Earth's shadow and the length of the winter night. By midnight on December 9/10, with the eclipse over, the Full Moon beams down from high in the sky. When the Full Moon lies nearly overhead, we see its light through the least amount of Earth's atmosphere. That's why the Moon appears exceptionally bright. And if snow covers the ground, the Full Moon will appear even more dazzling. Recall the words of Clement C. Moore, who wrote, "The moon on the breast of the new-fallen snow gave the luster of mid-day to objects below. . . ."

METEORS FOR THE LONG NIGHTS

Some people like the Moon best when it's gone from the sky. That's true for those who look forward each year to the Geminid meteor shower, often the most reliable time all year to relax outside under a dark country sky and watch "shooting stars" sizzle across the night sky. The Geminid shower has produced over a hundred meteors per hour in recent years. Unfortunately, this year's shower peaks on the morning of December 13, when the Moon is only a few days past full. Strong moonlight interferes with the shower. On the other hand, this is one of the few annual meteor showers that can be good to watch in the evening as well as before dawn. You might try watching between the end of twilight and moonrise on the evening of December 12 or 13.

DECEMBER'S PLANETS

Venus appears in the southwest after sunset. It shines brilliantly at magnitude –4.2 and cannot be missed or mistaken for any other object.

As this month passes, you will see another planet, **Saturn**, creep steadily closer to Venus. At magnitude 0.7, Saturn is much fainter than Venus, but like the other planet, it shines with an unwavering light. Then by month's end the two planets meet in the sky. Saturn and Venus are separated by just 1.1° on December 21. Six nights later, on December 27, the waxing crescent Moon joins with these planets to form a striking trio. Afterward, Saturn continues to move closer to the sunset glare, while Venus ascends higher each evening in the twilight sky. Venus will reach greatest eastern elongation next month.

Mars rises in the northeast about three hours after sunset when the month begins. By month's end, it rises while twilight still lights the sky. Mars is now moving in a retrograde manner in front of the stars of Gemini. It passed Pollux, the brightest star in Gemini, early last month. Now Mars moves back past Pollux, passing 3° south of the star on December 22.

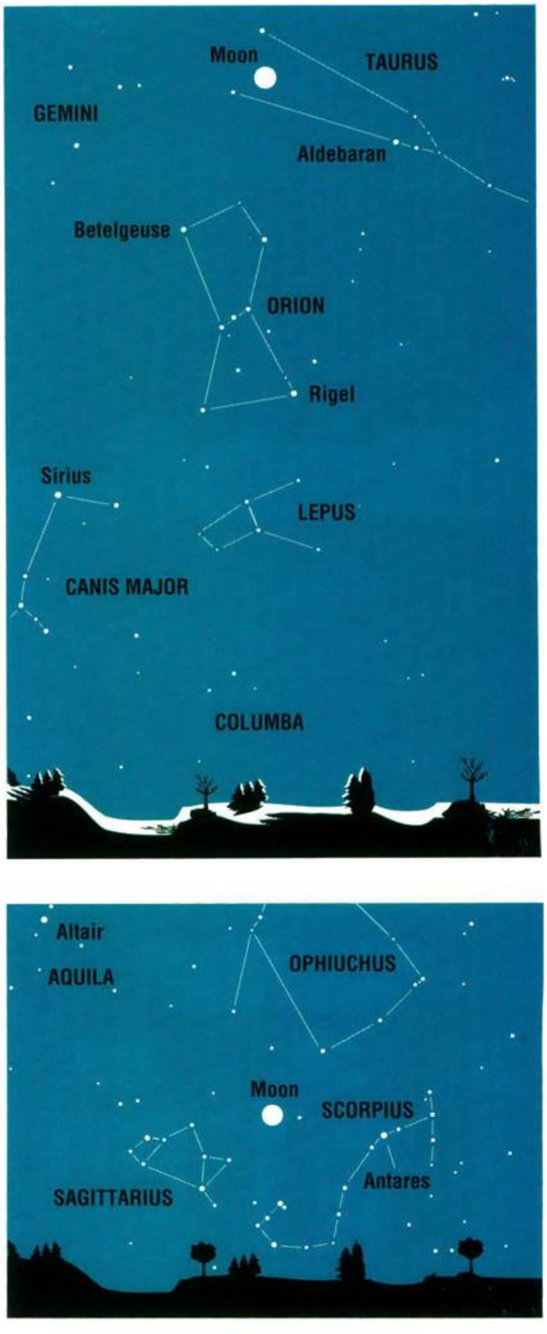
The Red Planet continues getting brighter and rising earlier as December progresses. By the end of the month, it is just a shade dimmer than Sirius, the sky's brightest star, at magnitude –1.4. Mars will reach another long-awaited opposition early in January.

December sees **Jupiter** rising after midnight and lying in the south at sunrise. It is very bright at magnitude –1.9, shining among the stars of Virgo. Jupiter lies 14° northwest of Spica, the brightest star in Virgo, when the month begins and 11° northwest when the month ends. Look for the Moon near Jupiter on the morning of December 17, and the Moon near Spica and Jupiter on the following morning.

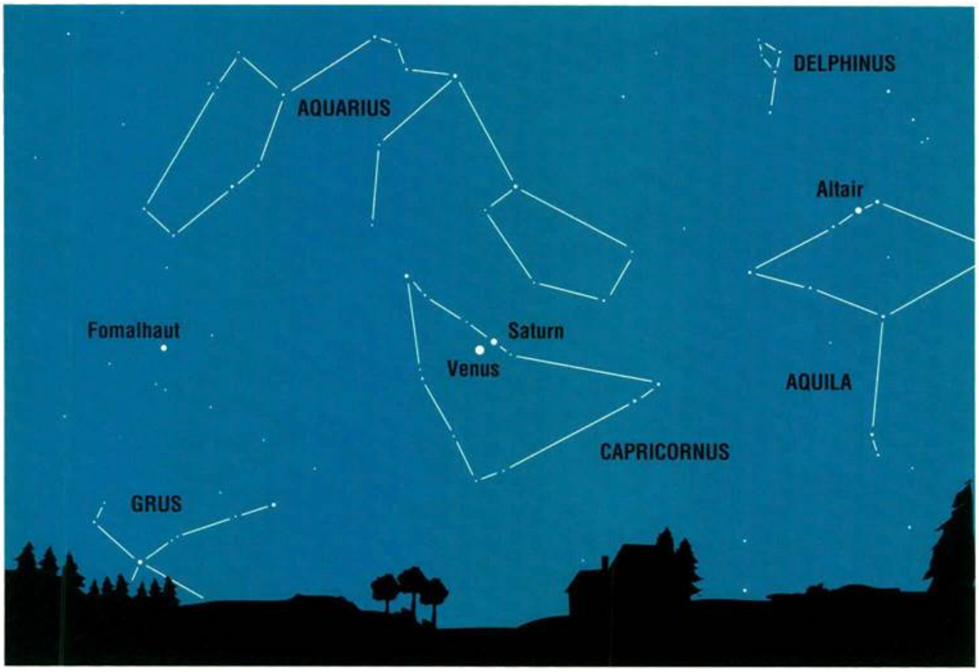
Mercury appears low in the southeast before dawn during the first three weeks of December. It grows brighter as the month passes, going from magnitude 0.5 to –0.5 in the course of the month. Greatest elongation comes on December 9, when Mercury lies 21° west of the Sun and for an observer at 40° north latitude appears 12° above the horizon 30 minutes before sunrise.

THE STARRY SKY

December is the darkest month for those of us in the Northern



THE FULL MOON ON DECEMBER 9/10 lies far above the southern horizon at local midnight, passing within 20° of the zenith for observers at 40° north latitude (top). Compare this with the Full Moon last June, which peaked less than 30° above the southern horizon (above).



VENUS AND SATURN MEET within the boundaries of Capricornus this month. Look for the pair on the evening of December 21, when they lie 1.1° apart in the southwestern sky as twilight fades into night.

Hemisphere. Poets have called it "the year's midnight." It's a time when the Sun travels its most southerly path across our sky and the days are at their shortest for the year.

Some people bemoan that it is "dark going to work and dark coming home." But in this era of electricity, we are far less vulnerable than our ancestors to the general melancholy of this month of least sunlight. Throughout history the December solstice has marked fervent celebrations for those in the Northern Hemisphere. After weeks of seeing the noontime Sun sink lower and lower in the sky — after increasingly shorter days and longer nights — the solstice arrives and the Sun's path begins shifting northward again. December festivals in many cultures have featured themes of the triumph of light over darkness.

Although it has less sunlight than any other month, December has traditionally been a time to celebrate the Sun. No one did that better than the ancient Egyptians, for whom the Sun was the source of religion and a metaphor for the cycle of being.

The primary Egyptian sun god was Re, who was often portrayed with the body of a man and the head of a hawk. Re was the Sun personified and the world's ruler. He was said to travel across the 12 domains of the sky in a celestial "boat of the day." At dusk, he exchanged the day-boat for a night-boat that carried him through the 12 domains of Tuat, the underworld. This voyage through the underworld was perilous. In the last domain Re did battle with a serpent of darkness, called Apep. The combat took place just before dawn, and if Re won, he again stepped into the boat of the day and sailed through daylight's 12 domains. Each of these domains, of course, represents one hour. This is the origin of our 24-hour day.

The Sun gave order to the world of the Egyptians. Not only day and night, but also the yearly cycle of light and darkness resided in the Sun's regular movements. As E. C. Krupp, director of Griffith Observatory in Los Angeles, once wrote, "Sunrise to sunrise, solstice to solstice, the sun's behavior is the world's order."

You can recognize and plot a bit of this order for yourself this month. The earliest sunsets of the year do not coincide with the year's shortest day. The solstice on December 21 has the fewest moments of daylight for us in the Northern Hemisphere. But the earliest sunsets come a few weeks before the shortest day and the latest sunrises come a few weeks afterward. This happens because Earth's orbit around the Sun isn't a perfect circle, and because the tilt of our planet's axis isn't aligned with the solstice. The exact dates of earliest sunset and latest sunrise depend on your latitude, but the sequence — earliest sunset, shortest day, latest sunrise — occurs the same way every year. Try noting the time of sunset and sunrise for a few weeks around this year's December solstice, and this sequence may become a permanent fixture in your awareness of the sky. ☐

LATEST SUNRISE AND EARLIEST SUNSET

North Latitude	Latest Sunrise	Earliest Sunset
20°	January 17	November 25
25°	January 13	November 29
30°	January 10	December 2
35°	January 7	December 5
40°	January 4	December 7
45°	January 2	December 9
50°	December 31	December 11
55°	December 29	December 13
60°	December 26	December 15
65°	December 24	December 18

Though December 21 is the shortest day of the year everywhere in the Northern Hemisphere, the dates of the latest sunrise and earliest sunset vary significantly with latitude.

Deborah Byrd's radio series, "Earth and Sky," can be heard on stations in the United States, Canada, and Guam.

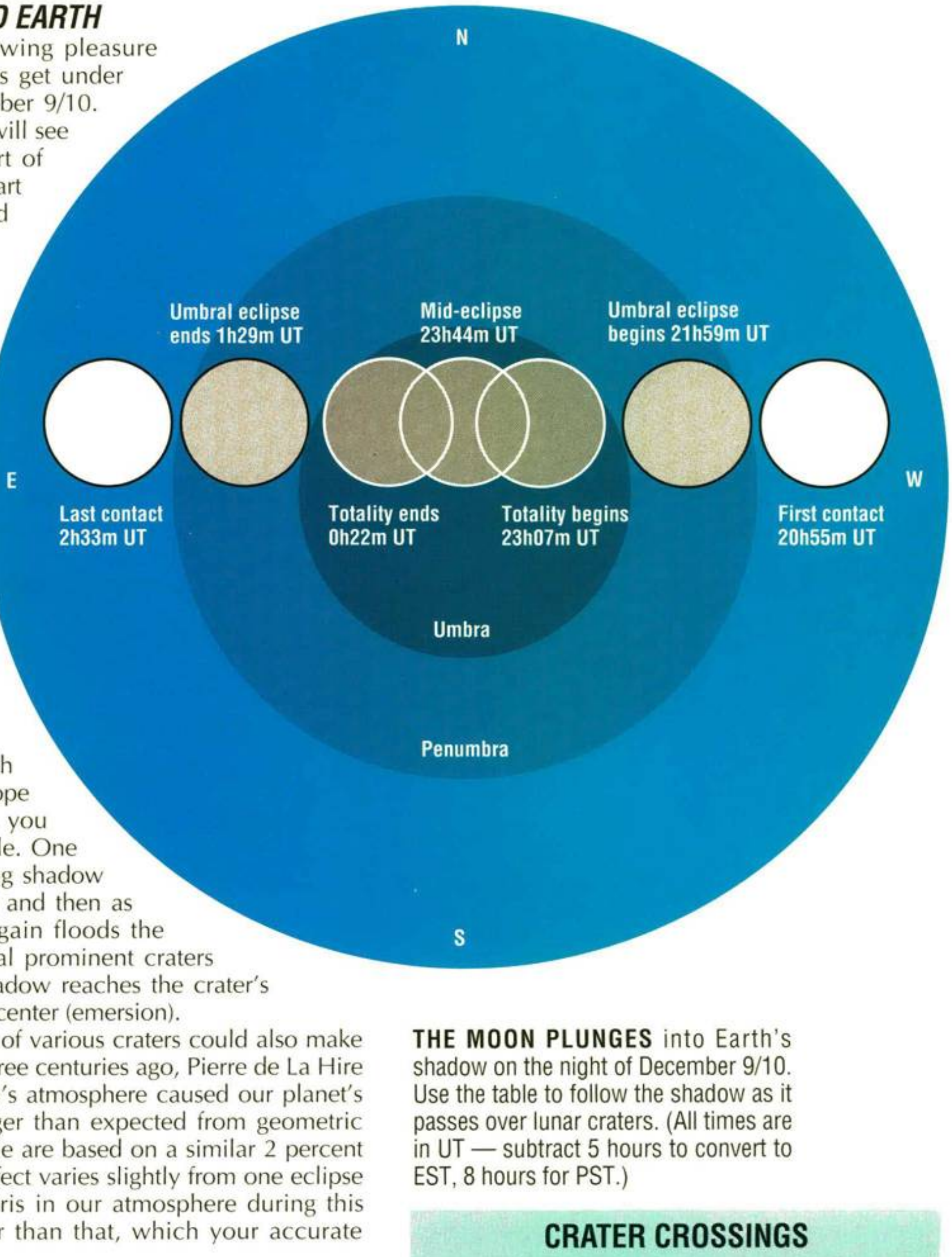
Through the Eyepiece *by Rick Shaffer*

SHADOWS ACROSS THE MOON AND EARTH

A pair of eclipses arrives for our viewing pleasure during this holiday season. The festivities get under way with a total lunar eclipse on December 9/10. Observers in most of the inhabited world will see the Moon pass through the northern part of Earth's shadow. For those in the eastern part of the Americas, Europe, Africa, and western Asia, the entire event is visible. From the western two-thirds of North and South America, the Moon rises after the eclipse has begun. And from eastern Asia, the Moon sets before the eclipse ends. (See "When the Moon Disappears" on page 70 for more details on viewing the eclipse.)

Just as the partial lunar eclipse of June 14/15 was quite dark, so should this one be. The reason is the large amount of sulfuric acid aerosols and volcanic ash spewed into our upper atmosphere by last year's eruption of Mount Pinatubo. How much effect they will have depends on how much of this volcanic debris remains, but expect the eclipse to be at least somewhat darker than normal.

Though it's fun to just relax and watch with your naked eye, binoculars, or telescope as a lunar eclipse plays out before you, you can also take a more active observing role. One way to do this is to view Earth's onrushing shadow as it first envelops a crater with darkness and then as the shadow leaves and sunlight once again floods the crater floor. The table at right lists several prominent craters and the predicted times when Earth's shadow reaches the crater's center (immersion) and leaves the crater's center (emersion).



THE MOON PLUNGES into Earth's shadow on the night of December 9/10. Use the table to follow the shadow as it passes over lunar craters. (All times are in UT — subtract 5 hours to convert to EST, 8 hours for PST.)

Carefully timing the shadow's crossing of various craters could also make an excellent science fair project. Nearly three centuries ago, Pierre de La Hire observed during a lunar eclipse that Earth's atmosphere caused our planet's shadow to measure about 2 percent larger than expected from geometric considerations. The times listed in the table are based on a similar 2 percent enlargement of the shadow, though the effect varies slightly from one eclipse to another. Because of the volcanic debris in our atmosphere during this eclipse, the shadow may be a bit larger than that, which your accurate measurements can confirm or deny.

The other holiday eclipse is a partial solar eclipse on December 23/24. The Sun rises in eclipse as seen from eastern Asia, while people in Japan will see the eclipse begin just after sunrise. The path of "partiality" then passes over Siberia and the Aleutians and ends when the Sun is setting in Alaska. (See page 52 of Eye on the Sky for the times and percent of maximum eclipse.) Although only observers in eastern Siberia can see the maximum partial eclipse (84 percent), most people in the northern Pacific Ocean will see the Moon take at least a small chunk out of the Sun.

If you plan to observe this event, remember that you risk permanent damage to your eyes if you look directly at the Sun at any time during the eclipse. To view the event safely, use a proper solar filter or project an image of the Sun onto a white card. A proper solar filter is a piece of #14, UV-coated welder's glass or a piece of aluminized Mylar plastic. Make sure the plastic has been manufactured specifically for viewing the Sun and not for thermal insulation or some other purpose.

To project an image of the Sun, take a piece of sturdy paper or cardboard

CRATER CROSSINGS

Crater	Immersion Time	Emersion Time
Grimaldi	22h05m	0h30m
Kepler	22h19m	0h39m
Tycho	22h20m	0h59m
Aristarchus	22h23m	0h32m
Copernicus	22h27m	0h47m
Pytheas	22h31m	0h45m
Plinius	22h49m	1h09m
Plato	22h49m	0h42m
Goclenius	22h49m	1h22m
Langrenus	22h54m	1h26m
Eudoxus	22h54m	0h54m
Taruntius	22h54m	1h20m
Aristoteles	22h56m	0h52m
Proclus	22h57m	1h18m

and cut a small hole in it. Then let the Sun's light pass through the hole and onto a white card placed several feet away. On the white card you'll see a fairly sharp image of the eclipsed Sun.

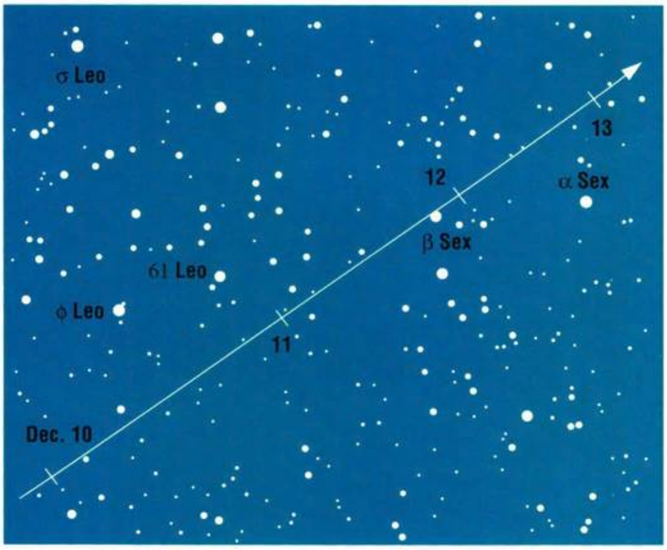
DON'T BLINK, OR YOU'LL MISS TOUTATIS

In the four and a half years since I started writing this column, I've normally described one asteroid each month that was particularly well placed for viewing. To appear in the column, an asteroid had to be brighter than 10th magnitude. Until now, this criterion meant that the lower-numbered asteroids, which tend to be the brightest and therefore discovered first, were all I included.

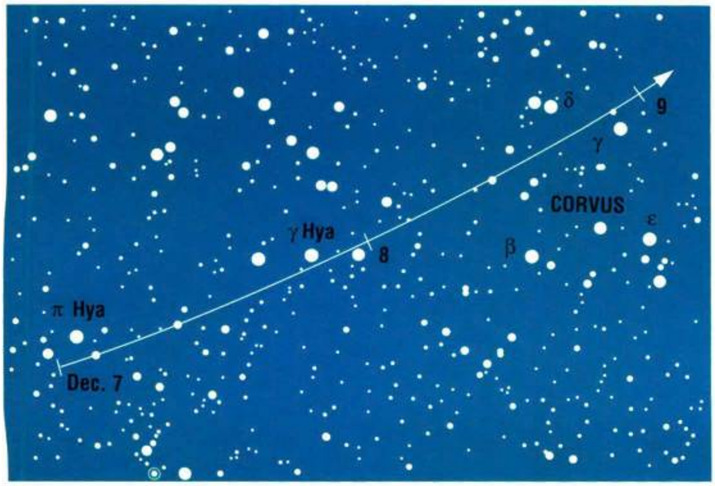
Asteroid 4179 Toutatis changes all that. No, it got neither bigger nor brighter. Nor did it become the first asteroid to hire an agent. What it has done is arrange to pass so close to Earth in December that it will briefly shine brighter than 10th magnitude.

Astronomers estimate that Toutatis will reach magnitude 9.4 on December 13, just five days after it passes closest to Earth. At closest approach on December 8, Toutatis shines at magnitude 11 and lies 0.024 astronomical unit, or 2.23 million miles, from Earth. Though this is only about ten times farther from Earth than the Moon, Toutatis' lit hemisphere then faces partly away from us and thus the asteroid doesn't appear as bright.

Because Toutatis passes so close to Earth, it races across our sky. It begins the month just east of the Sun in Sagittarius and then moves into conjunction with our star on December 4. By the 7th, Toutatis has moved nearly 30° along the ecliptic, leaving Scorpius and Libra behind and entering Hydra. During the rest of December it lies in the morning sky, passing through Corvus, Crater, Sextans, and Leo, before ending up in Cancer.



ASTEROID 4179 TOUTATIS comes into view in the morning sky around December 7, remaining visible until the end of the month. Positions are shown for 5 a.m. EST (4 a.m. CST, 3 a.m. MST, and 2 a.m. PST).



At its fastest around December 7, Toutatis moves considerably more than the diameter of the Full Moon — half a degree — every hour. As it passes stars, you should be able to see Toutatis move continuously. Later in the month, you'll have to photograph or sketch Toutatis' field and then return to the same field a night or two later. The "star" that changes position over that interval is Toutatis.

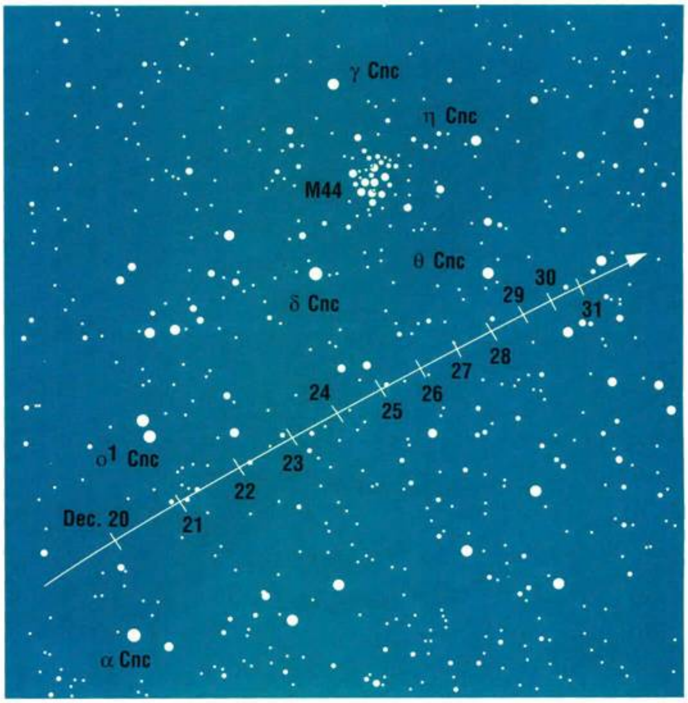
The maps and table of coordinates on these two pages will help you locate Toutatis throughout this month's observing window. But because Toutatis moves rapidly and shines at about 10th magnitude, we can't show all the stars to Toutatis' magnitude. (The maps on this page show stars to magnitude 8.0, those on the opposite page to magnitude

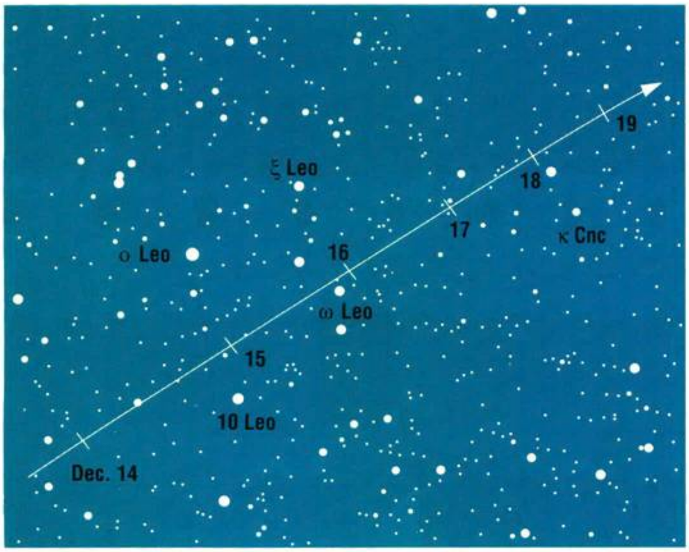
9.0.) To confirm your sighting of Toutatis, you have to detect its motion against the background stars.

TELESCOPIC PLANETS

Mercury has its best morning apparition of 1992 in December. You should be able to follow the planet during the first three weeks of December, when it lies low in the southeastern sky before sunrise. On December 1, the planet appears 8.3" across in your telescope's eyepiece and its disk is a 29-percent-lit crescent. At greatest elongation on December 9, Mercury shows a 6.7"-diameter disk that is 63 percent illuminated. And by the 20th, Mercury appears 5.5" across and its phase has swollen to 84 percent lit.

Venus had been hugging the western horizon throughout this evening apparition. Finally, in the last week of November, it climbed to a sunset altitude of 20° as seen from 40° north latitude. During December, the –4.2-magnitude planet climbs to over 30° elevation. In your telescope, Venus' 17.6"-diameter disk appears 66 percent lit.





On January 7, **Mars** reaches its biennial opposition to the Sun. Although this apparition doesn't feature an extremely close approach of Mars to Earth, it occurs when Mars appears high in the sky for Northern Hemisphere observers. The high altitude should give you many good, crisp views of the Red Planet. This month sees Mars brighten rapidly and grow in apparent size as it approaches opposition. On the 1st, the planet shines at magnitude –0.8 and its disk measures 12.8" across. By the 31st, Mars has nearly doubled in brightness to magnitude –1.4 and its diameter has grown to 14.9". For more details on observing Mars throughout its current apparition, see "Observing the New Mars" by Edward F. Albin in the November issue.

On December 21, Venus passes 1.1° south of **Saturn**. Unfortunately, Saturn is sinking toward the southwestern horizon with each passing night. Consider yourself lucky if you get a few good views of the ringed planet through the thick layers of air near the horizon. In your telescope, Saturn displays a 15.8"-diameter disk encircled by a ring system that spans 36.1".

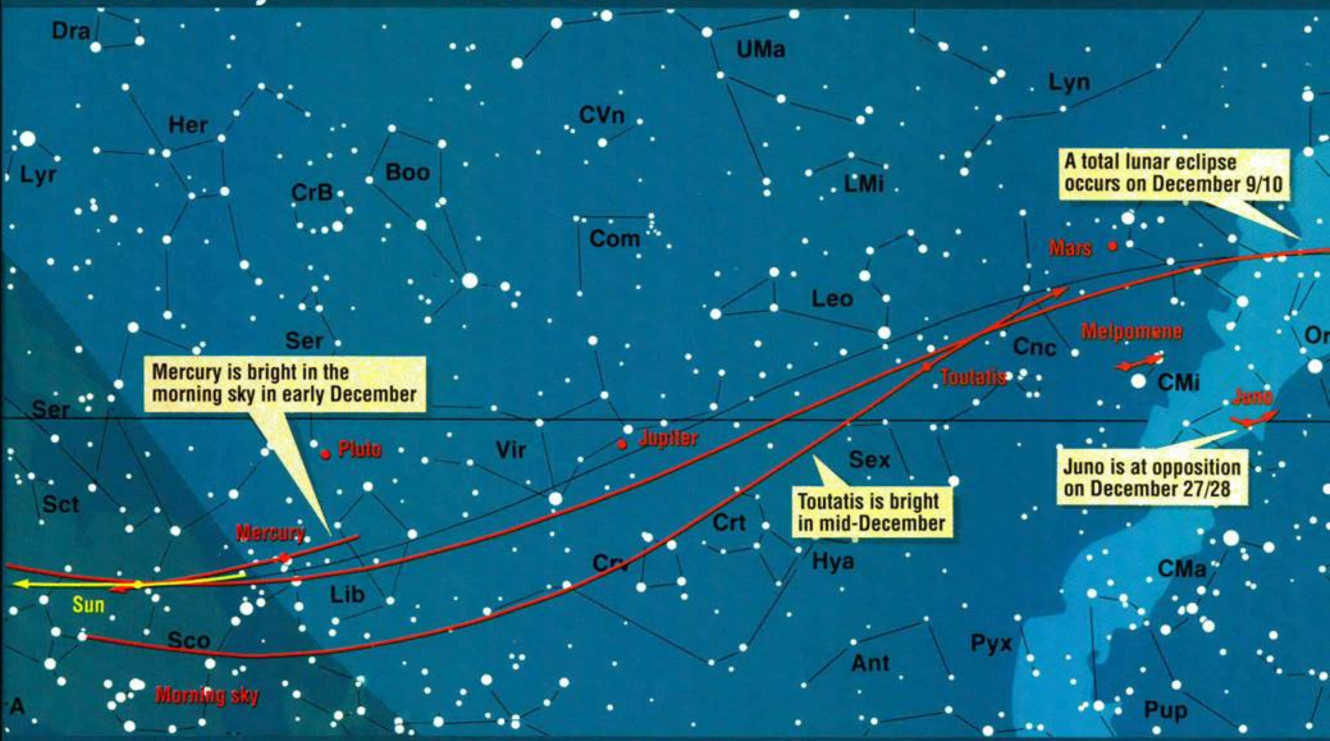
You can find **Jupiter** in the southeast before morning twilight begins. If you get a morning with good seeing, you should see easily the alternating dark bands and light zones that girdle the planet's 34.7"-diameter disk. ☐

Rick Shaffer is an engineer and writer in the aerospace industry in southern California.

COORDINATES FOR TOUTATIS

Date	R.A. (2000)	Dec.
Dec. 7	14h09.9m	–28°03'
Dec. 8	13h07.7m	–22°35'
Dec. 9	12h12.2m	–15°55'
Dec. 10	11h27.5m	–9°29'
Dec. 11	10h53.0m	–4°06'
Dec. 12	10h26.8m	0°08'
Dec. 13	10h06.5m	3°24'
Dec. 14	9h50.6m	5°55'
Dec. 15	9h37.9m	7°54'
Dec. 16	9h27.5m	9°30'
Dec. 17	9h18.8m	10°47'
Dec. 18	9h11.5m	11°51'
Dec. 19	9h05.2m	12°45'
Dec. 20	8h59.7m	13°31'
Dec. 21	8h54.9m	14°10'
Dec. 22	8h50.5m	14°45'
Dec. 23	8h46.7m	15°15'
Dec. 24	8h43.1m	15°42'
Dec. 25	8h39.9m	16°06'
Dec. 26	8h36.9m	16°28'
Dec. 27	8h34.2m	16°48'
Dec. 28	8h31.6m	17°06'
Dec. 29	8h29.2m	17°22'
Dec. 30	8h27.0m	17°38'
Dec. 31	8h24.9m	17°52'

The Solar System December 1992


Dra
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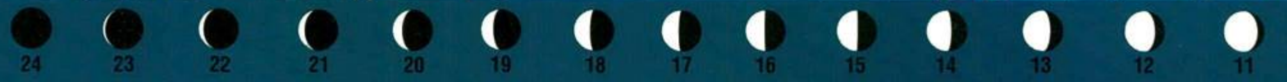
Com
Mars
Leo
Ser
Cnc
Melpomene
Or
Toutatis
CMi
Ser
Juno
Pluto
Vir
Jupiter
Sex
Sct
Crt
Mercury
Hya
CMa
Crv
Sun
Lib
Sco
Pyx
Ant
Morning sky
Pup
A

A total lunar eclipse occurs on December 9/10

Mercury is bright in the morning sky in early December

Toutatis is bright in mid-December

Juno is at opposition on December 27/28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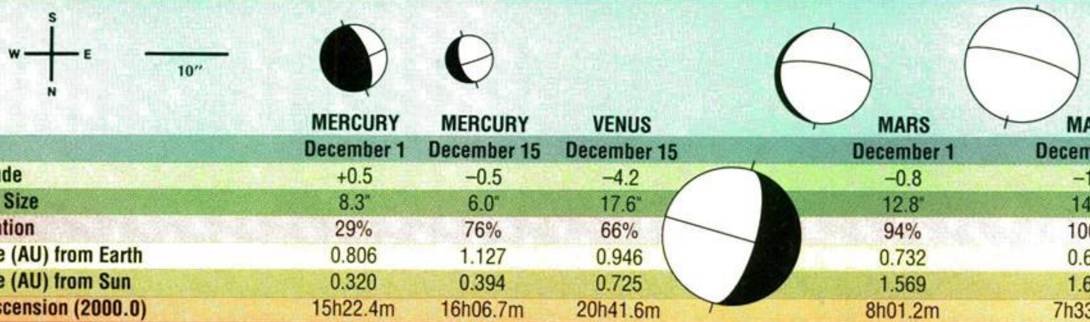
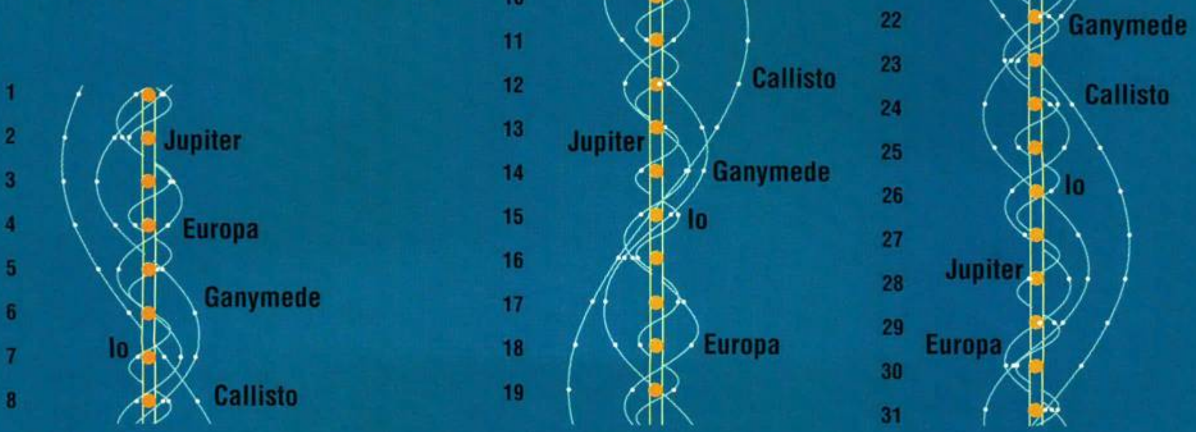
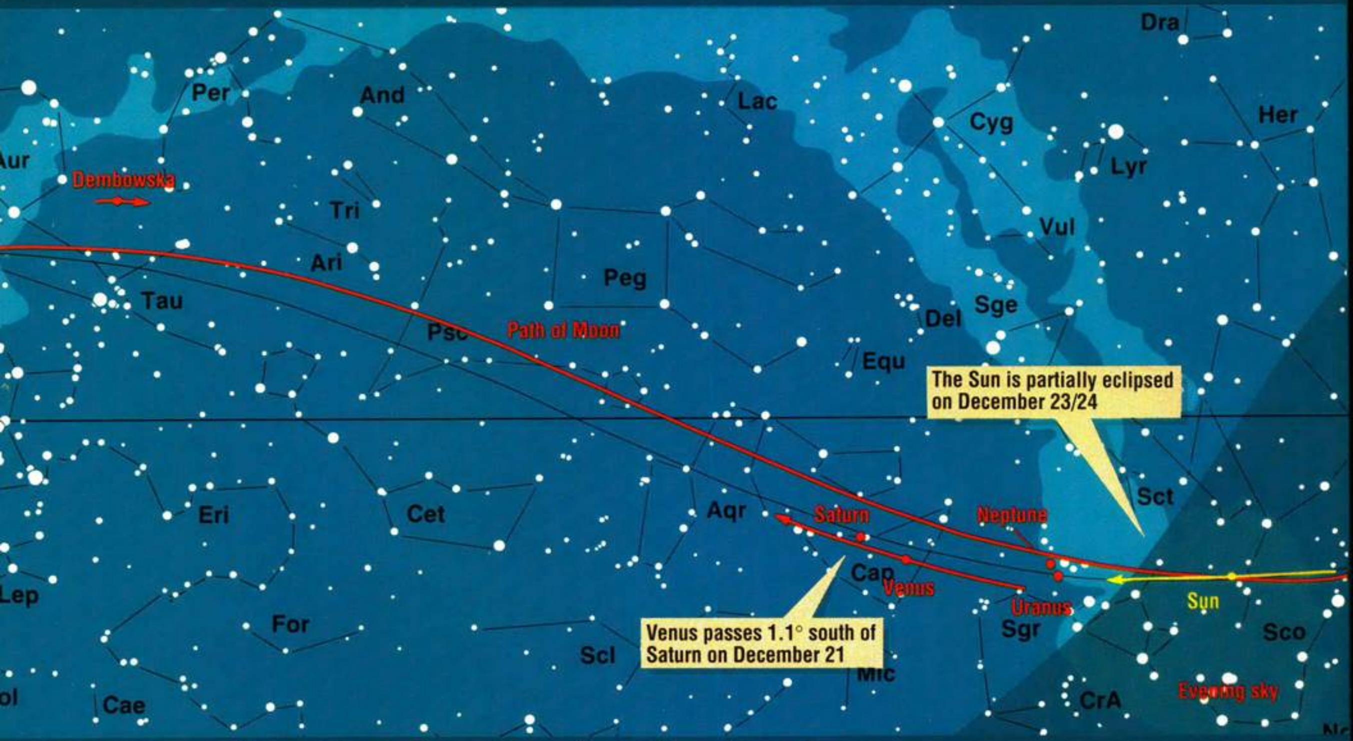


Planet	MERCURY	MERCURY	VENUS	MARS	MARS
Date	December 1	December 15	December 15	December 1	December 31
Magnitude	+0.5	–0.5	–4.2	–0.8	–1.4
Angular Size	8.3"	6.0"	17.6"	12.8"	14.9"
Illumination	29%	76%	66%	94%	100%
Distance (AU) from Earth	0.806	1.127	0.946	0.732	0.627
Distance (AU) from Sun	0.320	0.394	0.725	1.569	1.603
Right Ascension (2000.0)	15h22.4m	16h06.7m	20h41.6m	8h01.2m	7h33.0m
Declination (2000.0)	–15°52'	–19°09'	–20°34'	23°07'	25°37'

Jupiter's Moons

Dots display positions of Galilean satellites at 10 UT on date shown. South is at top to match the view in a telescope.

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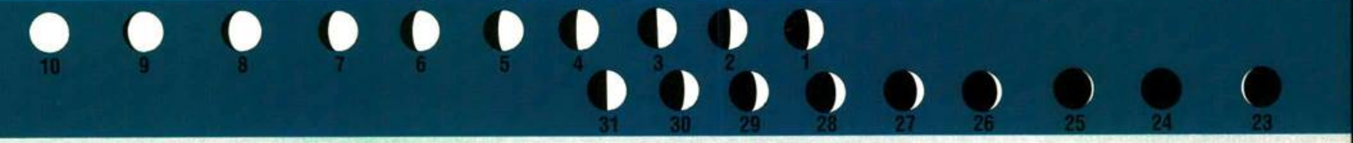
Evening sky

The Sun is partially eclipsed on December 23/24

Venus passes 1.1° south of Saturn on December 21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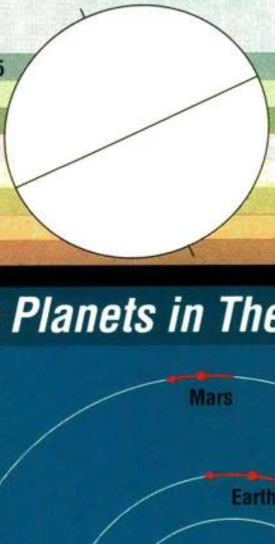
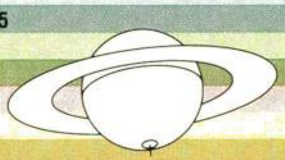
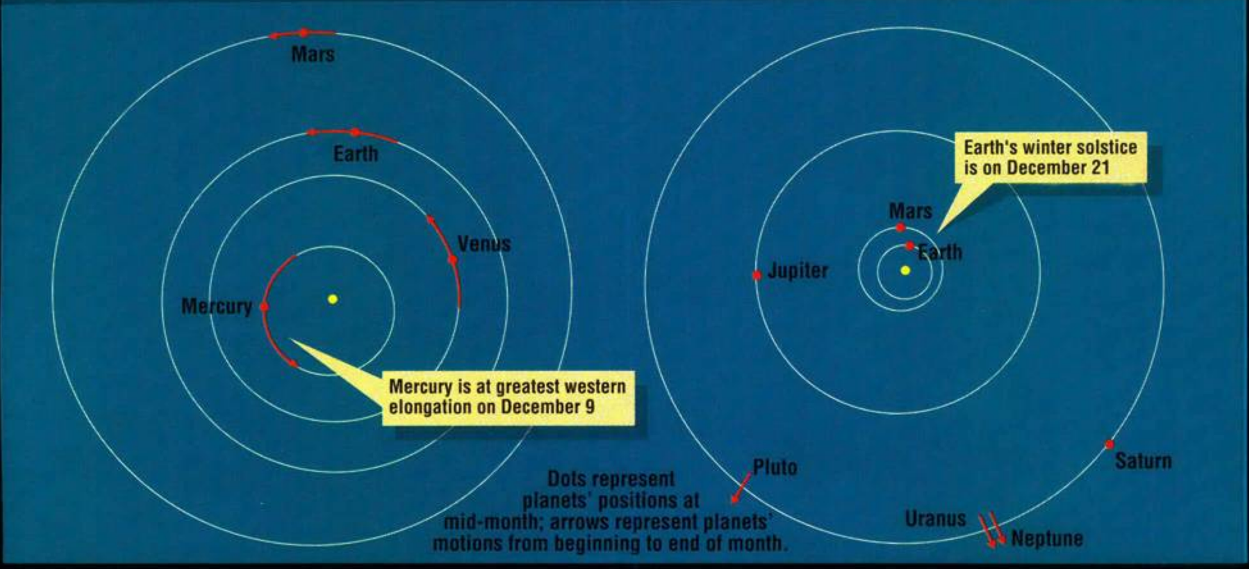




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
December 15	December 15	December 15	December 15	December 15
−1.9	+0.7	+5.8	+8.0	+13.8
34.7"	15.8"	3.4"	2.2"	0.1"
99%	100%	100%	100%	100%
5.676	10.452	20.469	31.081	30.546
5.446	9.868	19.569	30.188	29.718
12h45.3m	21h10.2m	19h13.0m	19h16.9m	15h40.9m
−3°31'	−17°22'	−22°48'	−21°35'	−5°06'

The Planets in Their Orbits


Mars
Earth
Venus
Mercury
Mars
Earth
Jupiter
Pluto
Saturn
Uranus
Neptune

Mercury is at greatest western elongation on December 9

Earth's winter solstice is on December 21

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

NEW MEADE® ADVANCED PRODUCTS AT LUMICON

"What an astounding combination of high performance and low price!" Jack Marling, Ph.D., owner of LUMICON

TOLL-FREE ORDER LINE 1-800-767-9576 EXPERT INFORMATION 1-510-447-9570 FAX 1-510-447-9589

NEW ED APOCHROMAT REFRACTORS

6'' f/9 Apochromat
Only $3995

NOTE: Add the indicated packing and shipping (P&S) costs to each telescope for shipment to your door.

Meade 6'' f/9 Model 152ED Refractor shown with #1697 Computer.

See the Meade ad in this magazine for full specifications and product descriptions. ED = Extremely low dispersion glass which yields color-free virtually perfect images. PPEC = Permanent Periodic Error Correction "Smart Drive."

Model 102 ED 4'' f/9 Apochromat & mount (add $105 P&S)	**$1795**
Model 127 ED 5'' f/9 Apochromat & mount (add $125 P&S)	**$2295**
Model 152 ED 6'' f/9 Apochromat & mount (add $185 P&S)	**$3995**
Model 178 ED 7'' f/9 Apochromat & mount (add $215 P&S)	**$4995**
Photographic field corrector lens (specify telescope model)	**$250**

DRIVE SYSTEMS

#1664 Electronic Drive with PPEC and 2X, 32X slewing system, dual-axis controller	**$295**
#1697 Computer Drive, 747 object computer memory, automatic slewing to desired object	**$595**
8,000 Object CNGC Library	**$99**
Polar alignment finder	**$99**
Optional optical encoders for #1697 drive	**$299**

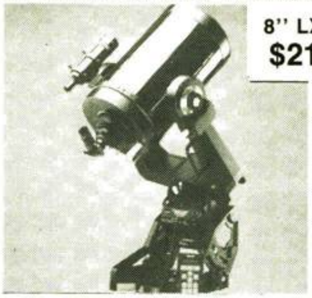
OPTICAL TUBE ASSEMBLIES (OTA)

Model 102 ED/OTA 4'' f/9 OTA only	**$1075**
Model 127 ED/APO-OTA 5'' f/9 OTA only	**$1595**
Model 152 ED/APO-OTA 6'' f/9 OTA only	**$2295**
Model 178 ED/APO-OTA 7'' f/9 OTA only	**$2995**

EQUATORIAL MOUNTS

LXD 600 mount and standard field tripod	**$895**
LXD 700 mount and giant field tripod	**$1995**

NEW MEADE LX100 & LX200 SCHMIDT-CASSEGRAIN TELESCOPES



8'' LX200
$2195

NEW MEADE 8'' LX200 TELESCOPES

See the Meade ad in this magazine for full specifications and details. **LX100 Drive**, 2X, 32X speed control with PPEC (Permanent Periodic Error Correction "Smart Drive") and dual-axis hand controller. **LX200 Drive**, Full electronic control with PPEC, 747 object computer memory and automatic computer controlled slewing to desired object. *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive.

8'' LX100 Schmidt-Cassegrain with wedge (add $105 P&S)	**$1795**
8'' LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2195**
Wedge for photographing with LX200	**$110**
10'' LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2595**
10'' LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2495**
Super Wedge for photography with LX200	**$395**
8,000 Object CNGC Library	**$99**
Polar alignment finder	**$99**

OTHER SCHMIDT-CASSEGRAINS

***NEW!* SSC-8**, 8'' Schmidt-Cass on LXD-600 mount (add $105 P&S)	**$1395**
***NEW!* SSC-10**, 10'' Schmidt-Cass on LXD-600 mount (add $125 P&S)	**$1695**
***NEW!* SSC-12**, 12'' Schmidt Cass on LXD-700 mount (add $195 P&S)	**$3495**
***NEW!* SSC-14**, 14'' Schmidt-Cass on LXD-700 mount (add $245 P&S)	**$4795**
Meade 2045D 4'' f/10 with motor drive (add $40 P&S)	**$599**
Meade 2080B 8'' f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
NEW! Model 2120B 10'' f/10 w/wedge, tripod, MCOG (add $125)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10'' f/5-f/10 operation	**$395**

MEADE STARFINDERS

8'' f/6
$649*

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6'' to 16'' Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (48X) eyepiece.

6'' f/8 Starfinder 6(add $50 P&S)	**$569**
8'' f/6 Starfinder 8 (add $60 P&S)	**$649**
10'' f/4.5 Starfinder 10 (add $75 P&S)	**$759**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$1995**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $96 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

Meade #43 Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$399**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — 4,000 OBJECTS!

With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON

Improved NGC SKY VECTOR with over 12,000 object memory including complete, corrected RNGC catalogue, IC catalogue, complete P&K planetary catalogue, and much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$169.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6x7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$235.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$59.50**
LUMICON 2'' Helical Focuser 1½'' high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' rack & pinion focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$169**
1¼'' right-angle 80mm SUPER-FINDER	**$179.50**
1¼'' right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼'' eyepiece (12X)	**$39**
1¼'' Star Diagonal **$39**, Mounting Brackets,	**$49.50**
1¼'' Amici Prism diag. for correct left-right views	**$89.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$26.00**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**16.00**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$26.00**
2'' long extension for 2'' eyepieces*	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$20.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON carries a full line of telescopes & accessories. Fast delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

The Double Cluster NGC 869 & 884 in Perseus. Photo by Martin Germano using an 8" f/5 Newtonian telescope, 15 minute exposure, 103a-F film. Mr. Germano used a LUMICON Newtonian EASY-GUIDER and LUMICON 2" Helical focuser to facilitate focus and guiding.

SALE!
BUY 2, GET 1 FREE!!

TELE VUE EYEPIECES

Genesis 4" f/5 4 element fluorite	$1560
Pronto 70mm f/6.4 apochromat w/2" diagonal	$698
Pronto 70mm f/6.4 w/Porro prism	$649
Complete Equatorial Mount	$795
Motor Drive for above mount	$198
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$89
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow - 2x	$219
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 65°	$145
24mm Wide-Field, "superb," 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "awesome," 65°	$299
4.8mm Nagler, 82° field	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, "the best"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$179
2" Paracorr Visual Coma Corrector	$298
NEW! **22mm Panoptic 1¼"/2", 68°**	$249
NEW! **35mm Panoptic 2", 68° field**	$325

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$49.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (510) 447-9570
FAX (6 PM-9 AM PST) (510) 447-9589
LUMICON Products catalogue FREE
All foreign orders add 8% ($10 minimum)
California residents add 8.25% tax.
Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 11 am - 3 pm

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$29.95**	1.52"	**$34.50**	1.83"	**$39.50**
2.14"	**$49.50**	2.60"	**$65.00**	3.10"	**$89.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

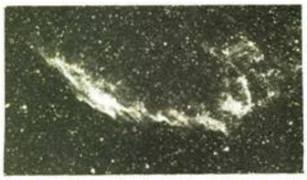
AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
Astronomy, Feb. 1991

	Premium*
0.96" **LUMICON DEEP-SKY Filter** threads into most 0.96" eyepieces	$59.50
1¼" **LUMICON DEEP-SKY Filter** threads into most 1¼" eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm	**$279.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines **1¼" $99.50, 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$16.00
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$20.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

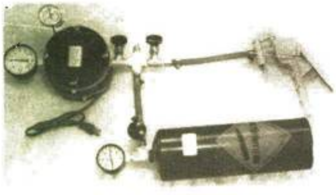
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

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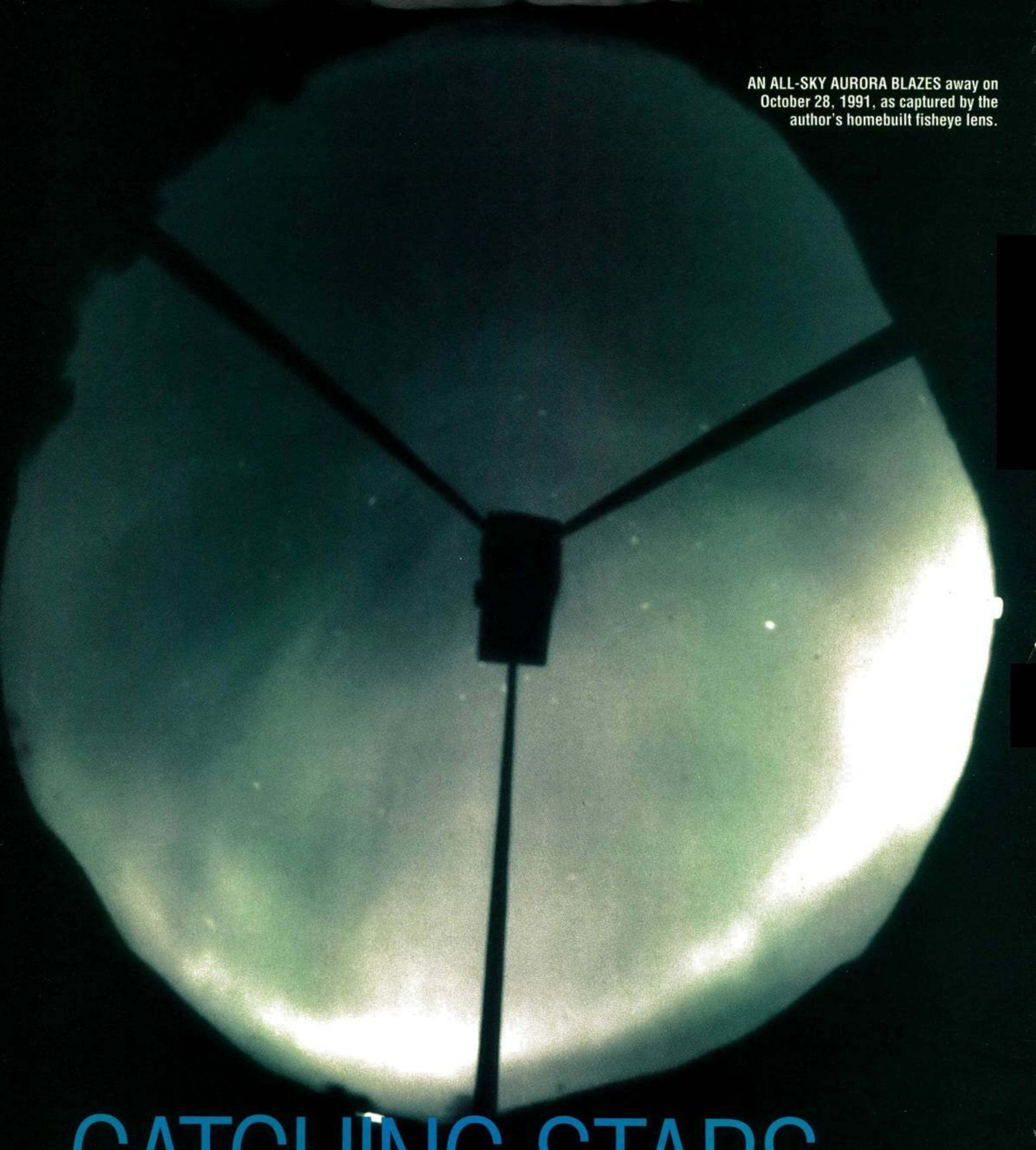


AN ALL-SKY AURORA BLAZES away on October 28, 1991, as captured by the author's homebuilt fisheye lens.

CATCHING STARS IN A HUBCAP

An all-sky fisheye lens costs a bundle. Here's one you can build for about $15.

Story and photos by Peter Zaffo

Astrophotography is a great way to record celestial sights. Yet some subjects — all-sky auroras, the Milky Way, intense meteor showers — are so large that you need a 180° field of view to capture them.

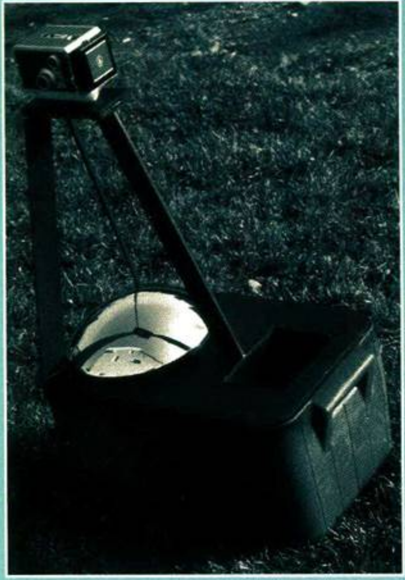
But if spending upwards of $1,000 on a fisheye lens gives you pause, check out the nearest auto-parts store or junkyard. Look for a convex hubcap with a chromed mirror finish. Known to hotrodders as a "baby moon" or "moon disk," one of these placed on the ground will reflect the entire sky if you (or a camera) stand over it and look down.

OK, the image isn't perfectly sharp. It's also reversed left-for-right and distorted near the edges; moreover, the camera and the tripod holding it will block part of the view. However there's no beating the price! A 10" diameter baby moon costs about $6 from the NAPA chain of auto-parts stores and a junkyard may charge less. With the additional wood and paint, you'll be hard-pressed to spend more than $15 on this.

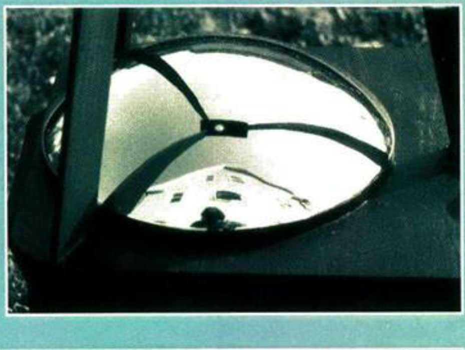
Because the camera and tripod inevitably block part of the view, a tall tripod beats a short one since the camera will loom smaller in the image. However, long tripod legs can become too long for easy handling and, more important, they move the camera farther from the mirror, thus reducing the size of the sky image on the film. The solution to the dilemma is to use a short telephoto lens: in effect, you pull the camera back to reduce its presence in the image but use a longer focal length lens to fill the image frame with the mirror.

My camera is a twin-lens reflex but the tripod will carry any camera with only slight modifications. The camera looks down into the mirror, which is mounted on a "tabletop" made of $^{1}/_{4}$" plywood. The tabletop sits in turn atop an old 48-quart plastic picnic cooler, which raises the tripod above the grass or snow. (The cooler is optional, but it helps prevent dewing on the mirror.) I rimmed the underside of the tabletop with $^{3}/_{4}$" x $^{1}/_{2}$" quarter-round molding to hold it in place on the cooler. For convenience I also built a cubicle into the tabletop next to the tripod legs to hold the camera during transport.

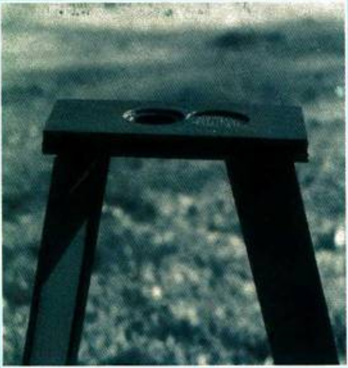
My homemade tripod consists of three legs made from $^{1}/_{4}$" lattice wood each cut to a length of $18^{1}/_{2}$". Each leg inclines at an angle of 16° from the vertical and is glued into a slot cut out for it into the tabletop. I painted the tripod and tabletop with flat black enamel to cut stray light reflections.



SMALL, LIGHT, AND TRANSPORTABLE, a cheap fisheye lens is simple to make from scrap wood and an auto hubcap.



A GLEAMING CHROME "BABY MOON" hubcap lies below the downward-pointing camera and reflects the entire sky.



EASILY CUSTOMIZED to suit individual cameras, the platform sits atop the tripod legs and provides a hole for the camera lens to look down through.

FOR CONVENIENCE AND SAFETY the author inserted a carrying cubicle for his twin-lens camera into the table top.

The camera platform sits atop the tripod legs. The platform on mine measures $6^{1}/_{2}$" long by 3" wide by $^{5}/_{8}$" thick. Since I was building with a twin-lens camera in mind, I cut two circular openings slightly larger than the outer diameters of the lens barrels of the twin-lens camera. If you have an SLR you can make the platform square with only one hole for the lens to look down through. Other ideas for mounting the camera are possible — and of course, you can even use a standard photo tripod.

The heart of the instrument is the mirror, a baby moon hubcap 10" in diameter. Be sure it has a chrome mirror finish (not brushed aluminum) and plan to give it an extra buff with polish. To mount it on the tabletop, I cut a circle from $^{1}/_{4}$" plywood sized to fit just inside the inner diameter of the hubcap. I then glued this to the top of the board and press-fitted the baby moon over it. You could also hold it in place with three short strips of scrap wood mounted around the circumference.

The whole assembly is a 1-piece instrument that requires no knockdown for transport. Because it is only 18" high, I can carry it easily and set up quickly, a real plus with fast-changing auroras.

Your camera needs to be able to take time exposures. (Look for a B or T setting.) Aurora photos run about 30 seconds to a minute on ISO 400 film. If you don't want to be in the picture, use the camera's self-timer to trip the shutter when you've gotten a short distance away. To end the exposure, walk up quickly and close the shutter. The mirror can also be used in daytime to take all-sky pictures of weather systems, cloud formations, solar halos, and so on. ☐

Peter Zaffo is an atmospheric scientist and amateur astronomer.

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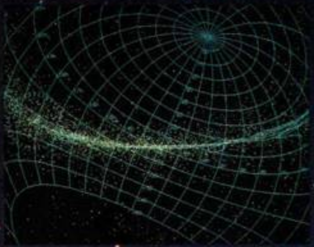

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TAKING PICTURES WITH YOUR TELESCOPE

Here are step-by-step instructions showing how to connect your camera to a telescope and begin your astrophotography adventure.

by Alan Dyer

Telescopes and cameras just naturally go together. Many people buy their first telescope with the idea of attaching their camera to take pictures of what they see through the eyepiece. If you want to take pictures with your telescope, the first thing you need to do is connect your camera to your telescope. There are several types of camera adapters on the market, making the choice a bit confusing. Which is the one you want? Will it fit on your scope? What kind of pictures can you take with it?

Before placing your order for a camera adapter, the first thing you need to consider is what type of telescope you have. If you own one of the popular Schmidt-Cassegrain telescopes, or SCTs, your task of selecting astrophoto accessories is a snap. All the SCTs on today's market are offered with a selection of adapters and brackets specifically designed for those models, and the manufacturers' brochures clearly illustrate each of the accessories.

If you have a reflector or refractor telescope, the manufacturer might have camera adapters and mounting brackets specifically made for your model. Increasingly, many of the mounts and telescopes available today are sold as the nucleus of complete astrophoto systems. In this case, you are probably best to stick with the accessories made specifically for your scope, as they'll be sure to fit.

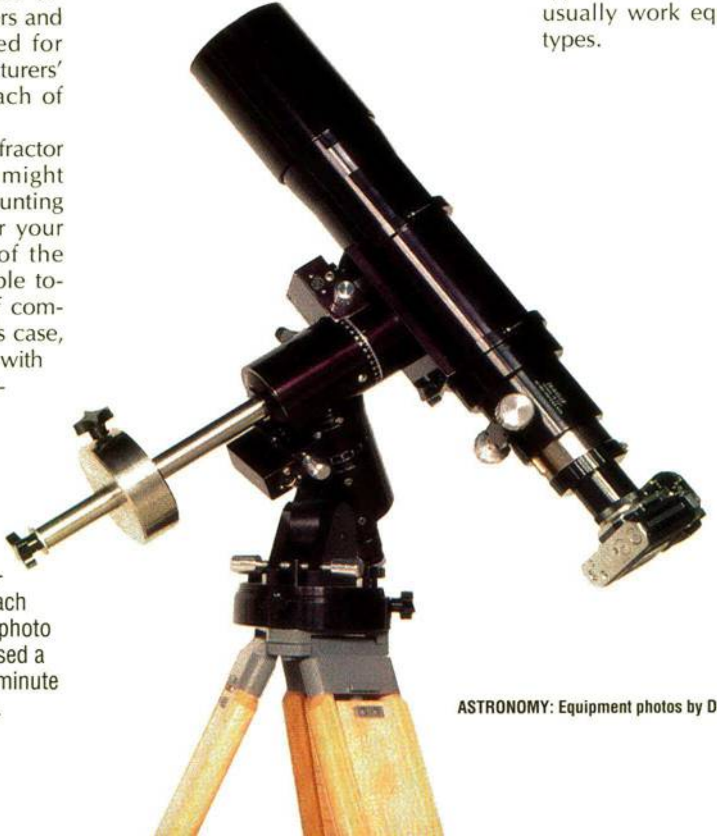
Many refractor and reflector owners have to rely on using general-purpose or "universal" adapters that are designed to fit a wide range of telescopes. These are available from your local telescope store or from any of the mail order telescope dealers. But fully outfitting some reflectors or refractors for astrophotography can sometimes require a little ingenuity.

You can choose from among several variations of the basic camera-to-telescope adapters depending on what type of celestial object you are after. Long-exposure photographs of deep-sky objects can require a different adapter than the basic scope-to-camera coupling needed for shots of the Moon. Close-up shots of lunar craters or a planet's disk require a different adapter yet again.

There are basically four types of astrophotography with a telescope, each with its own adapters:

- Prime focus (good for snapshots of the Sun and Moon)
- Eyepiece projection (used for close-up shots of the Sun, Moon, and planets)
- Piggyback (used for guided wide-angle shots of starfields taken with a camera lens)
- Guided prime focus (used for long-exposure photos of deep-sky objects taken through the telescope)

We've illustrated the adapters for each of these techniques by type of telescope, breaking them down into those used on Schmidt-Cassegrains and those used on other types of telescopes such as most refractors and reflectors. These telescopes have focuser tubes that accept standard-sized eyepieces and accessories. The typical universal camera adapters usually work equally well on these types.

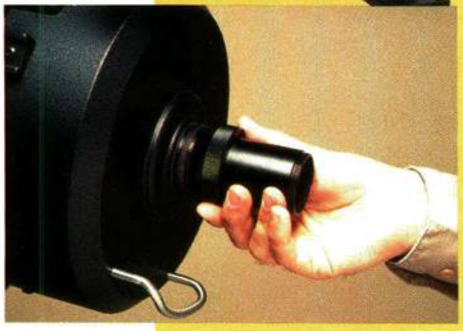


GREAT ASTROPHOTOS can come from any well-mounted telescope. A critical first step is selecting the right accessories to attach your camera to the scope. For his photo of the Orion Nebula, Scott Hicks used a 12.5-inch f/4.8 reflector and a 25-minute exposure on Konica 400 print film.

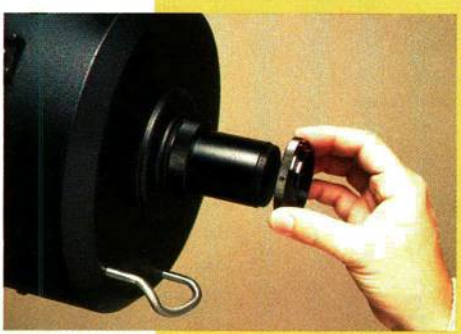
ASTRONOMY: Equipment photos by Darla Gawelski

PRIME-FOCUS PHOTOGRAPHY

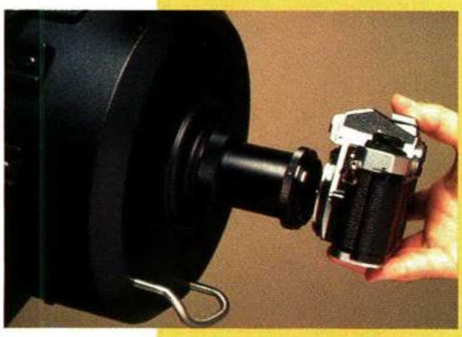
WITH A SCHMIDT-CASSEGRAIN



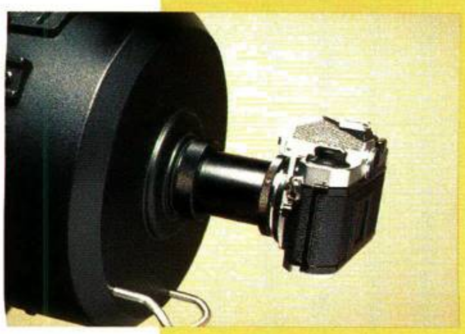
1. Attach the T-adapter to the threaded backplate of the telescope.



2. Screw a T-ring for your camera onto the universal threads of the T-adapter.

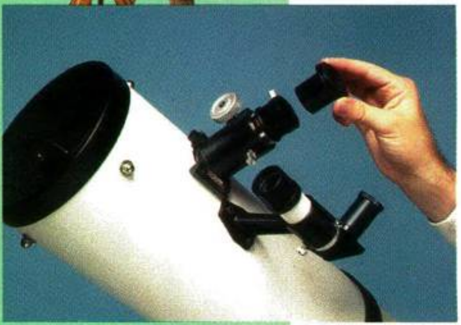


3. Twist the camera body onto the T-ring.

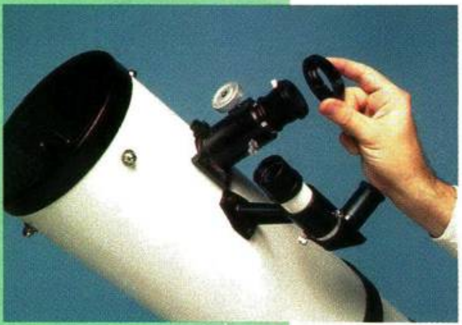


4. The prime-focus adapter is ready. To frame your subject, loosen the T-adapter's threaded collar and rotate the assembly.

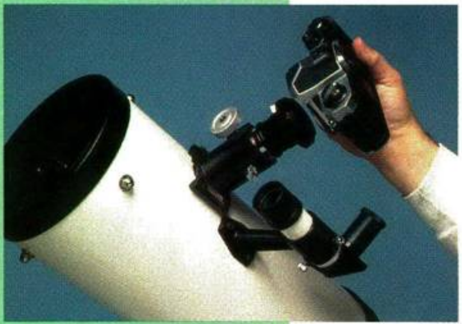
WITH REFLECTORS AND REFRACTORS



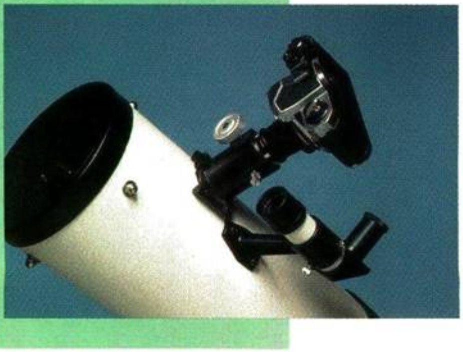
1. As if you are inserting an eyepiece, slide the prime focus adapter into the empty focuser.



2. Screw a T-ring for your camera onto the universal threads of the adapter.



3. Twist the camera body onto the T-ring.



4. The prime-focus adapter is ready. To frame your subject, loosen the focuser's lock screw *and* rotate the assembly.

The simplest way to take pictures through your telescope is to use the prime-focus technique. You'll need a 35mm single-lens reflex (SLR) camera to do the job but chances are that's what you already own. An SLR has interchangeable lenses, allowing you to remove the standard lens and replace it with optional wide-angle, telephoto, or zoom lenses.

For prime-focus photography, remove the lens entirely and use the camera body alone. You also don't need an eyepiece on the telescope. Instead, the scope's main lens or mirror projects its image directly onto the film. Attaching your telescope in this manner creates an ultra-long telephoto. For example, if yours is an f/10 scope with a focal length of 2,000 mm, then you've got a 2000mm f/10 telephoto. Quite a lens!

You'll use this technique most often for shots of the whole disk of the Moon and Sun (although in the case of solar photography you'll also need a safe solar filter over the front aperture of the telescope).

To do prime-focus photography you need a basic coupler. In the case of Schmidt-Cassegrain telescopes it is called a T-adapter and sells for about $25. To use it, remove the "visual back" that holds your star diagonal and eyepiece and screw the T-adapter onto the threads that are part of the scope's backplate.

For other telescopes you need a prime-focus or "universal" camera adapter. This $30 device slips into your focuser tube in place of the eyepiece. When ordering one, be sure to get the model that will fit your focuser. Most telescopes have focusers with 1 1/4-inch tubes. Some scopes have the smaller 0.965-inch focusers. In that case you'll need an adapter that has a 0.965-inch barrel.

Some telescopes have 2-inch or even 2.7-inch focusers. You can buy 2-inch-diameter adapters for these. Two-inch adapters can be more expensive but have the advantage of not cutting off, or "vignetting," the corners of the frame. The smaller adapters produce vignetted images because even a 1 1/4-inch adapter has an inside tube diameter of about 30 mm, less than the 35mm width of the film frame. However, for shots of the whole disk of the Sun and Moon this slight vignetting isn't a problem since the corners of the frame are dark anyway.

In addition to the basic camera adapter, no matter what type or size it is, you'll also need what's called a T-ring. But not just any T-ring. You need the one made for your brand of camera. Most telescope dealers and camera stores stock T-rings — the ones for 35mm cameras cost $15 to $20.

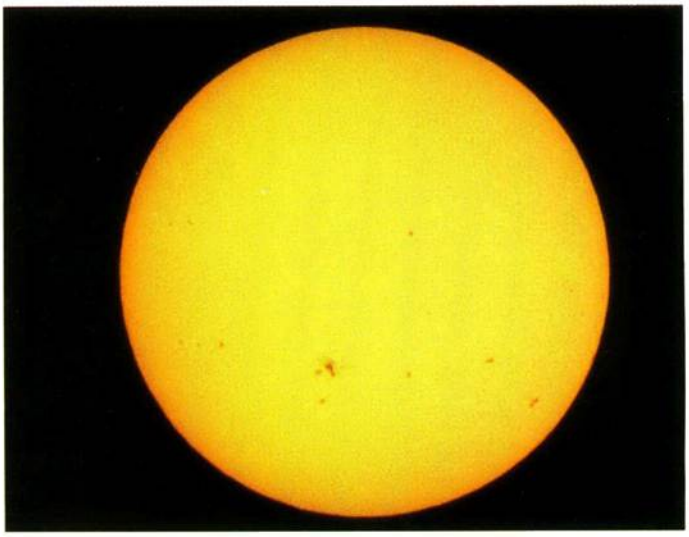
T-rings are a necessity because each of the many brands of cameras on the market has a different type of lens mount. To get around this, all telescope-to-camera adapters are made with a universal T-thread at the camera end. The T-ring screws onto this thread. The T-ring then bayonets into your camera body just like a lens. The advantage to this T system is that if you decide to switch to a different brand of camera, you don't need to scrap all your adapters. You just need a new, inexpensive T-ring.

A variation on the prime-focus technique is to insert a Barlow lens into the light path. This works for reflectors and refractors. Insert the prime-focus adapter and camera into the Barlow as if it were an eyepiece; then slide the Barlow into the focuser. This will give you a modest increase in magnification. For example, a 2x Barlow will double your telescope's focal length, providing a larger lunar or solar image.

You may be wondering what to do if you don't have a removable-lens SLR camera (perhaps all you own is a point-and-shoot pocket camera). Under these circumstances your telescopic photography options are limited. One method available to you that we've not illustrated is a technique called the "afocal method." This involves aiming a camera (with its lens still attached and focused for infinity) into the eyepiece. This technique is useful only for shots of the Moon and Sun because they don't need to be tracked. Astrophotographers who use the afocal method usually place the camera on a separate tripod arranged so the camera looks into the telescope eyepiece. However, these setups are difficult to keep focused as the telescope moves. Afocal setups can produce badly vignetted frames and often yield poor image quality. For the best results, you should avoid the afocal method and use an SLR camera without its lens.

However, an area where afocal photography *is* often required is video astrophotography of the Sun, Moon, and planets. If you cannot remove the lens from your camcorder (only the most expensive video cameras feature removable lenses), simply aim the video camera lens into the eyepiece of a scope (use a low-power eyepiece). For sharp results it's best to mount the camcorder rigidly in front of the eyepiece. This usually requires a homemade bracket since commercial camcorder-to-scope adapters are rare.

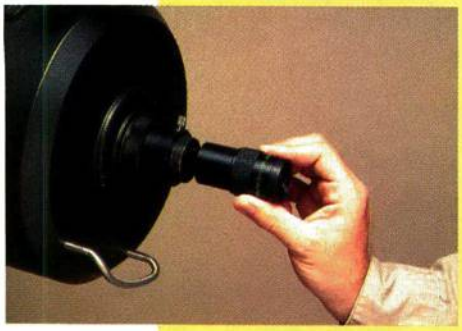
THE MOON IS A POPULAR TARGET for prime-focus photography. Kerry Hurd used a 10-inch f/6 reflector and a 5-second exposure on ISO 400 film.



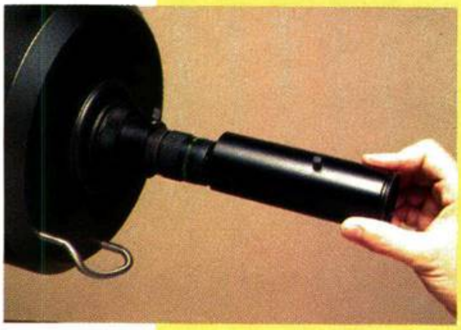
FOR A PRIME-FOCUS PORTRAIT of the Sun, William Sterne used a 90mm f/11 Maksutov telescope and a 1/500-second exposure on Ektar 25 film.

EYEPIECE PROJECTION PHOTOGRAPHY

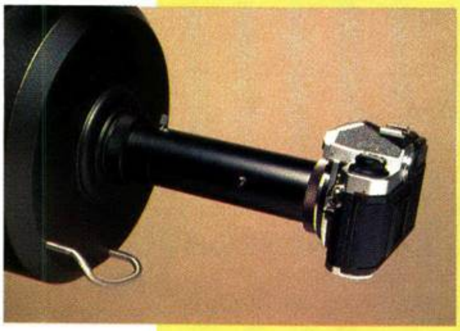
WITH A SCHMIDT-CASSEGRAIN



1. Insert an eyepiece into the visual back. Be sure to lock the eyepiece in place!

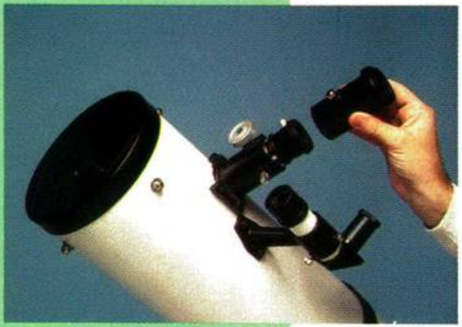


2. Slide the tele-extender tube over the eyepiece and screw it onto the visual back's threaded collar.

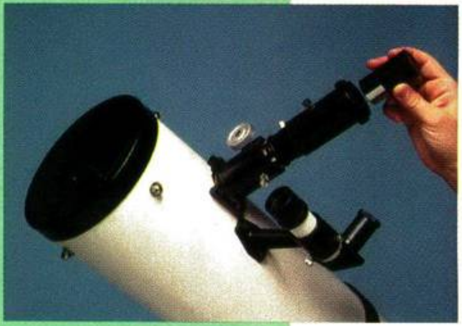


3. Attach the T-ring and camera to the tele-extender. But look out! The scope will now be out of balance. Loosen the mount's locks carefully.

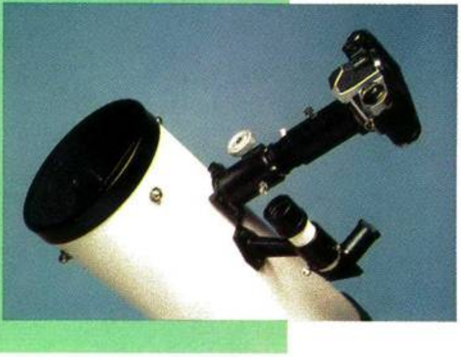
WITH REFLECTORS AND REFRACTORS



1. Screw the extension tube (with a T-ring) onto the basic prime-focus adapter.



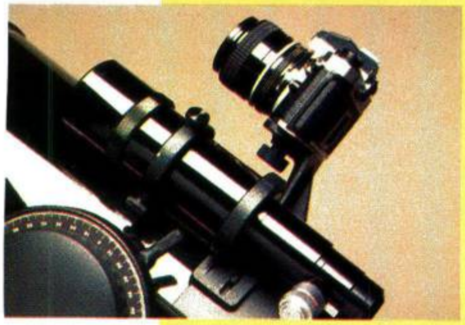
2. Slide an eyepiece into the extension tube. Be sure to lock the eyepiece in place!



3. Attach the camera to the T-ring. Rebalance the telescope and the projection setup is ready.

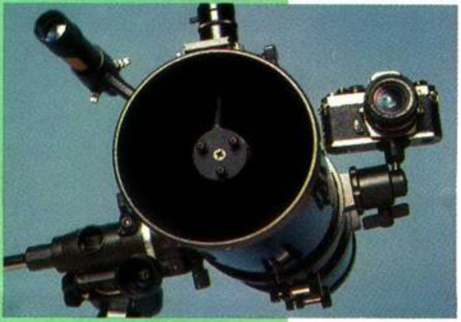
PIGGYBACK PHOTOGRAPHY

WITH A SCHMIDT-CASSEGRAIN



Attach the camera to the piggyback bracket by using the tripod socket on the baseplate of the camera.

WITH REFLECTORS AND REFRACTORS



A ball-and-socket head bolted to the tube rings allows you to tilt the camera to any angle for framing constellations.

Prime-focus photography with most telescopes produces an image of the Sun or Moon 10 to 20 mm across. This is enough to show details such as sunspots and craters. But for closeups of the spots and craters you need to turn to eyepiece projection — an eyepiece projects a highly magnified image into the lensless camera body and onto the film.

Besides being useful for lunar and solar closeups, this technique is the only way to get the planet disks large enough on the frame to show any detail.

If you use a Schmidt-Cassegrain, you need what the manufacturers call a tele-extender. This eyepiece projection tube screws onto the visual back of the telescope, slipping over an eyepiece inserted into the back.

If you are using a reflector or refractor, the prime-focus camera adapters usually come with an extra extension tube. Use this tube only when you want to do eyepiece projection. (If you try to use the extension tube when doing prime-focus photography, chances are you won't be able to get the telescope to focus.) The extension tube screws onto the prime-focus coupler. You then slide an eyepiece into the tube.

Like prime-focus adapters, tele-extenders and extension tubes have universal threads on their camera ends. To couple your camera to these tubes, you again need a T-ring.

There are a couple of things to look for with eyepiece projection adapters. The tube that contains the eyepiece should have a screw on the side of it. This either locks the eyepiece in place or acts as a stop to prevent the eyepiece from sliding down into your camera body. Also, be sure your eyepieces will fit inside the projection tube. Many of today's eyepieces (in particular ones with rubber grip rings) may be too wide to fit inside. Check with your dealer or manufacturer to make sure your eyepieces are compatible with the adapter you intend to buy.

Another potential problem is that if the eyepiece is too close to the camera, you'll get a vignetted image — the circle of light projected by the eyepiece won't be large enough to fill the frame. To avoid this you may need to add another extension tube. (Some projection adapters have sliding tubes to allow you to vary the projection distance. This also boosts the power — the farther the eyepiece is from the film, the more magnification you'll get.) If you have too short a projection distance, you can avoid vignetting (as well as boost magnification) by inserting a higher power eyepiece.

FOR A LUNAR CLOSEUP, Gregory Terrance used an 8-inch SCT and a 26mm eyepiece in a projection setup for his 2-second exposure on Kodachrome 25 film.

PLANET PORTRAITS demand eyepiece projection. For his Jupiter shot, Mark Payne-Gill used an 8.5-inch f/6 reflector and a 3-second exposure on Fujichrome 100.

Piggybacking a camera to the side of a clock-driven telescope lets you use the scope as a tracking platform during the exposure, typically 1 to 30 minutes.

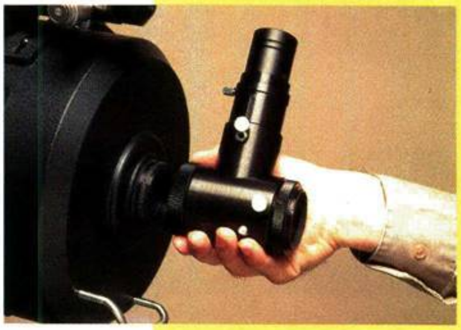
For a Schmidt-Cassegrain, get a bracket that bolts to the top of the tube; then attach the camera to it. This is a solid arrangement, but with wide-angle lenses the end of the tube can appear in the photo. To prevent this some brackets have adjustments to point the camera away from the tube.

Telescopes on German equatorial mounts sometimes have optional accessory rings available that clamp around the tube for holding a camera. Other scopes have 1/4-20 bolts or bolt holes on the main tube rings themselves. Use these fittings to attach a ball-and-socket tripod head. The head should be a heavy-duty model. Any sturdy tripod head might do, but with a ball-and-socket head you can easily flip the camera 90° (or to any angle you like) to frame the starfield. Without this ability, your piggybacked camera may end up turned vertically when your scope is aimed to the south, usually not the best orientation for framing constellations.

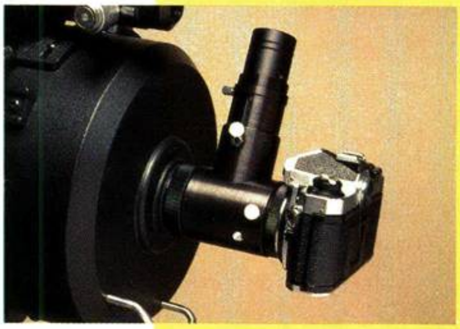
FOR THE SWORD OF ORION, Merry Edenton Wooten used a 135mm f/2 lens and a 15-minute exposure on Ektachrome 400.

GUIDED PRIME-FOCUS PHOTOGRAPHY

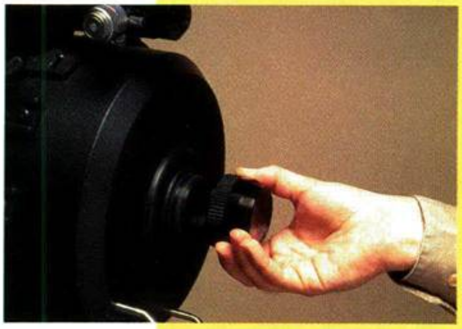
WITH A SCHMIDT-CASSEGRAIN



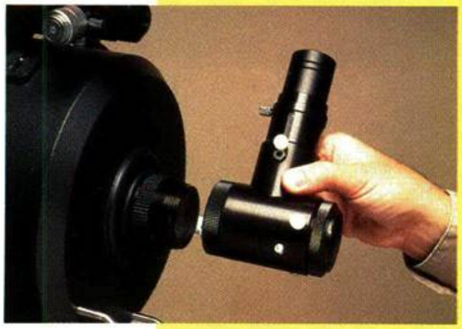
1. Attach the off-axis guider body to the threaded backplate of the telescope.



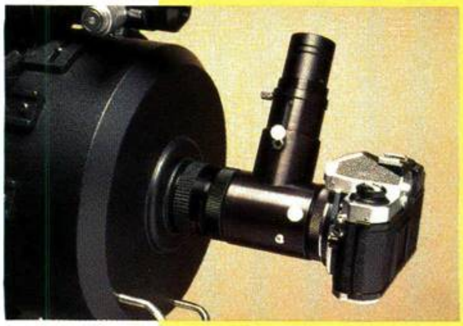
2. Attach a T-ring and camera body to the guider. Insert an illuminated reticle guiding eyepiece into the guider.



OPTION —
1. Screw a telecompressor onto the telescope. This lens reduces exposure times.

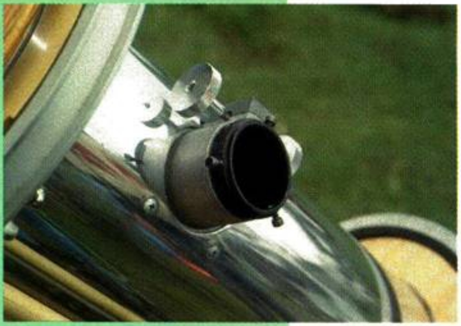


2. Attach the guider body to the telecompressor.

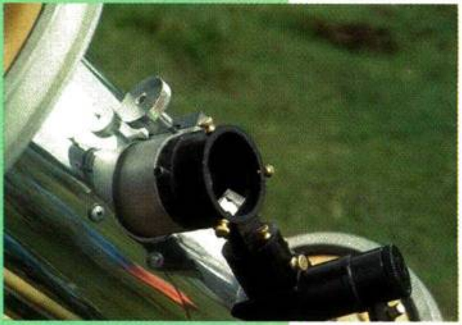


3. Both the camera and guiding eyepiece now receive "telecompressed" light and both will need to be refocused.

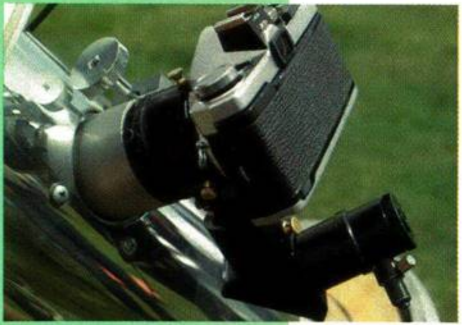
WITH REFLECTORS AND REFRACTORS



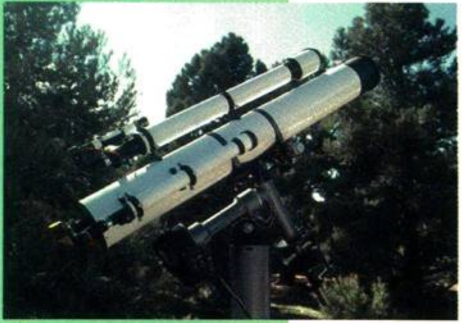
1. If you have a 2-inch focuser you may be able to use an off-axis guider with your reflector or refractor.



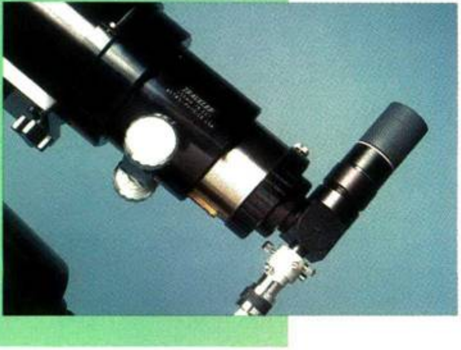
2. The guider slides into the focuser. The small prism picks off a guide star from the field edge.



3. The star diagonal places the guiding eyepiece at a convenient angle to look through.



ALTERNATIVE —
A separate guidescope can make it easier to locate a guidestar while allowing you to frame the subject the way you want in the main scope.



ALTERNATIVE —
Instead of using a dedicated guiding eyepiece, this accessory projects an illuminated reticle into the field of any eyepiece. It is ideal for use with guidescopes.

Taking long-exposure photos of deep-sky objects (nebulae, star clusters, and galaxies) through your telescope is the most demanding type of astrophotography. You might think all you need is a prime-focus adapter. Just hook up your camera to your telescope, turn on the clock drive, and walk away for a half hour or so.

If you do that you'll be in for a rude awakening. The photo will record your deep-sky target, but just barely, and the stars will look like wiggly worms. Don't worry, there's nothing wrong with your telescope drive. Yes, the drive does compensate for the apparent motion of the sky and will keep objects in the field, but no drive runs so accurately that you can walk away from the scope during a long exposure.

Dramatic improvements in the tracking accuracy of drives have been made in the last few years (innovations such as periodic-error-correction circuits, for example), but no drive will keep star images precisely on the same spot on the film for long exposures. Slight errors in the gears will cause the stars to wander back and forth in an east-west direction. Less than perfect polar alignment of the mount will cause the stars to drift in a north-south direction. All kinds of other subtle effects can give your deep-sky photos a case of the jitters.

To keep the stars looking like points, you need a way of monitoring a star near your target object. While the exposure is under way, you tweak the position of the telescope (preferably using electronic fine-speed adjustments on both axes of the telescope) to keep the star centered in a guiding eyepiece equipped with illuminated crosshairs.

The preferred method for guiding a Schmidt-Cassegrain is to use an "off-axis guider." This device screws onto the backplate of the telescope. The camera, with the T-ring, then attaches to the other end of the guider body. Partway down the guider body sits a small prism that juts into the light path. It picks off a star from the edge of the field and directs its image to the guiding eyepiece.

An option with Schmidt-Cassegrains is to insert a telecompressor into the light path. This accessory effectively shortens the focal length and speeds up the f/ratio of the scope (an increase from f/10 to f/6 is common), giving smaller but brighter images. The benefit is significantly reduced exposure times, as much as four times shorter.

The telecompressor screws onto the telescope; then the guider attaches to the telecompressor. Because some telecompressors require refocusing the telescope, they often come with an extension tube that raises the height of the guiding eyepiece, allowing it to reach the new focus point.

A few manufacturers offer off-axis guiders for Newtonian reflectors. These can be used on some refractors as well — check with the manufacturer for compatibility. They are designed for use with 2-inch focusers. They feature a very narrow body because an off-axis guider that puts too much distance between the camera and the top of the focuser would never focus — you wouldn't be able to rack the focuser in far enough to compensate for the thickness of the guider.

As an alternative to off-axis guiders, many owners of reflectors and refractors prefer to use a second telescope piggybacked on the main scope. This guidescope need only be a 2.4- or 3-inch refractor but it must have enough focal length (500 to 1000 mm) to provide enough power (100x to 400x) to allow you to detect small movements of the guide star. (Low-power finderscopes won't do the job.) The guidescope must also be securely attached to the main scope, never shifting inadvertently. If it does, you will end up correcting for movements of the guide star caused by shifting of your guidescope, not by mistracking of your drive. This will *create* trailed star images, not prevent them. On the other hand, the guidescope's support rings should have adjustment screws so you can move the guidescope around to search for a suitable guide star.

Some telescopes have bolts or holes in their rings or tube to facilitate attachment of rings for guidescopes. But in some cases, you'll need to drill holes in your tube if you want to stack another scope onto your existing tube.

If you use a guidescope, the only type of adapter you'll need for attaching your camera to the main scope is a simple prime-focus coupler. You insert an illuminated crosshair eyepiece into the guidescope and you're set. As an alternative, you can buy a nifty device that projects an illuminated bull's-eye pattern into the field of any eyepiece, allowing you to use your favorite eyepiece for guiding. These "projection reticle" accessories are designed for use with separate guidescopes.

Whatever route you choose, taking well-guided deep-sky photos is a challenge, but the results are immensely satisfying. ☐

A 25-MINUTE GUIDED EXPOSURE with an 11-inch f/11 Schmidt-Cassegrain captured the Orion Nebula. Kim Zussman used hypersensitized Konica 1600 print film.

THE SHORTER FOCAL LENGTH of a 16-inch f/4.5 Newtonian resulted in a smaller Orion Nebula. Jim Egger used a 45-minute exposure on Ektachrome 400.

TOTAL LUNAR ECLIPSE

WHEN THE MOON DISAPPEARS

On the night of December 9/10, much of the world will experience the first total lunar eclipse in nearly three years.

by Alan Dyer and Richard Talcott

Backyard observers have endured an unusually long stretch without a total lunar eclipse. But the wait is now over. On the night of December 9/10, a totally eclipsed Moon will hang in the sky for people in most of North and South America and nearly all of Europe, Asia, and Africa. Those in the Americas haven't seen a total eclipse since the dazzling one in August 1989, while those in the rest of the world have waited since February 1990.

However, the Moon could appear significantly different than it did during these total eclipses of the recent past. If the partial eclipse this past June is any guide, the Moon will grow much darker than normal as it traverses Earth's shadow. Thank last year's eruption of Mount Pinatubo in the Philippines, which injected tons of debris into our upper atmosphere that will block much of the sunlight trying to reach the Moon.

The big unknown is whether skies will be clear for the eclipse. In many parts of the Northern Hemisphere, December is the cloudiest month of the year. But when the weather does clear, the night sky often takes on a clarity you don't find in other seasons. If that happens, the eclipsed Moon should look spectacular against a black background interspersed with the brilliant, glittering stars of winter.

Moonrise over America

Observers in North and South America will get their first glimpse of the eclipsed Moon at or shortly after the Moon rises late on the afternoon of December 9. Look for the Moon to climb above the northeastern horizon between about 4 p.m. and 5 p.m. local time.

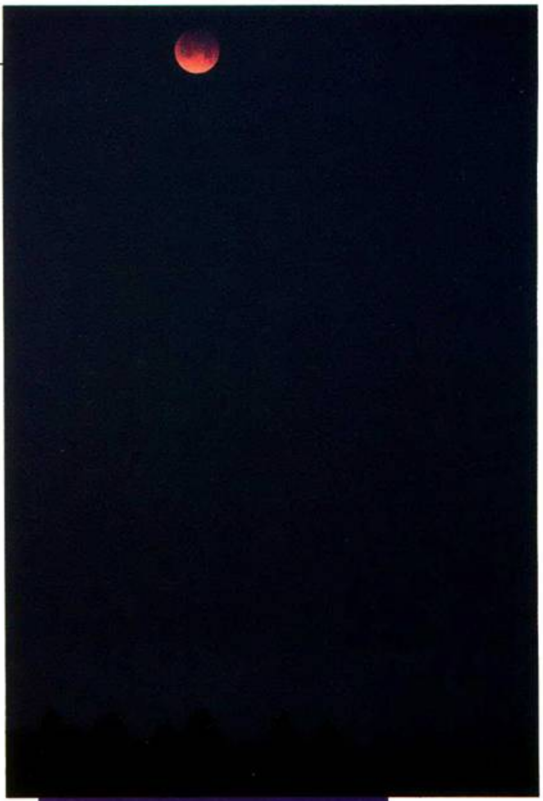
TERENCE DICKINSON: August 16, 1989, 5-inch f/6 refractor with 2x Barlow giving f/12, Kodachrome 200, 20 seconds.

In North America, you'll see more of the eclipse the farther east you live. The best place to be is in the extreme northeastern United States or eastern Canada. Only from these locations does the Moon rise before the eclipse begins. First contact between the Moon and Earth's penumbra — the outer, lighter part of the shadow — comes at 20h55m universal time, or 3:55 p.m. EST. (Astronomers reckon time using a system known as universal time, or UT, which is based on a 24-hour clock. You can convert UT to your local standard time by subtracting 4 hours for AST, 5 hours for EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.)

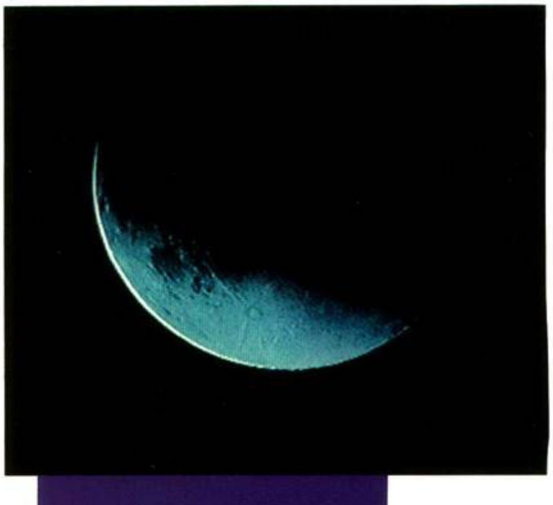
But don't despair if you live elsewhere. It takes a keen eye to spot the subtle shading the penumbra gives to the otherwise Full Moon. The real action starts when the Moon enters the dark, inner part of Earth's shadow known as the umbra. That's when the partial phase of the eclipse begins, and shortly after you'll notice a small bite taken out of the Moon's western limb.

The Moon enters the umbra at 21h59m UT, which is after moonrise for much of northeastern North America. You'll be able to see the start of the partial phase if you live east of a line that runs from the coast of the Carolinas northwest through western Virginia, western Ohio, western Michigan, the arrowhead of Minnesota, northwestern Ontario, central Manitoba, and into the southern Northwest Territories.

If you live west of that line, the partial phases will have begun by the time the Moon pokes above the horizon. Still, you'll get to see part of the partial phases and all of totality if you're east of a line running from eastern Texas northwest through the Great Plains into eastern Montana, Saskatchewan, and Alberta.



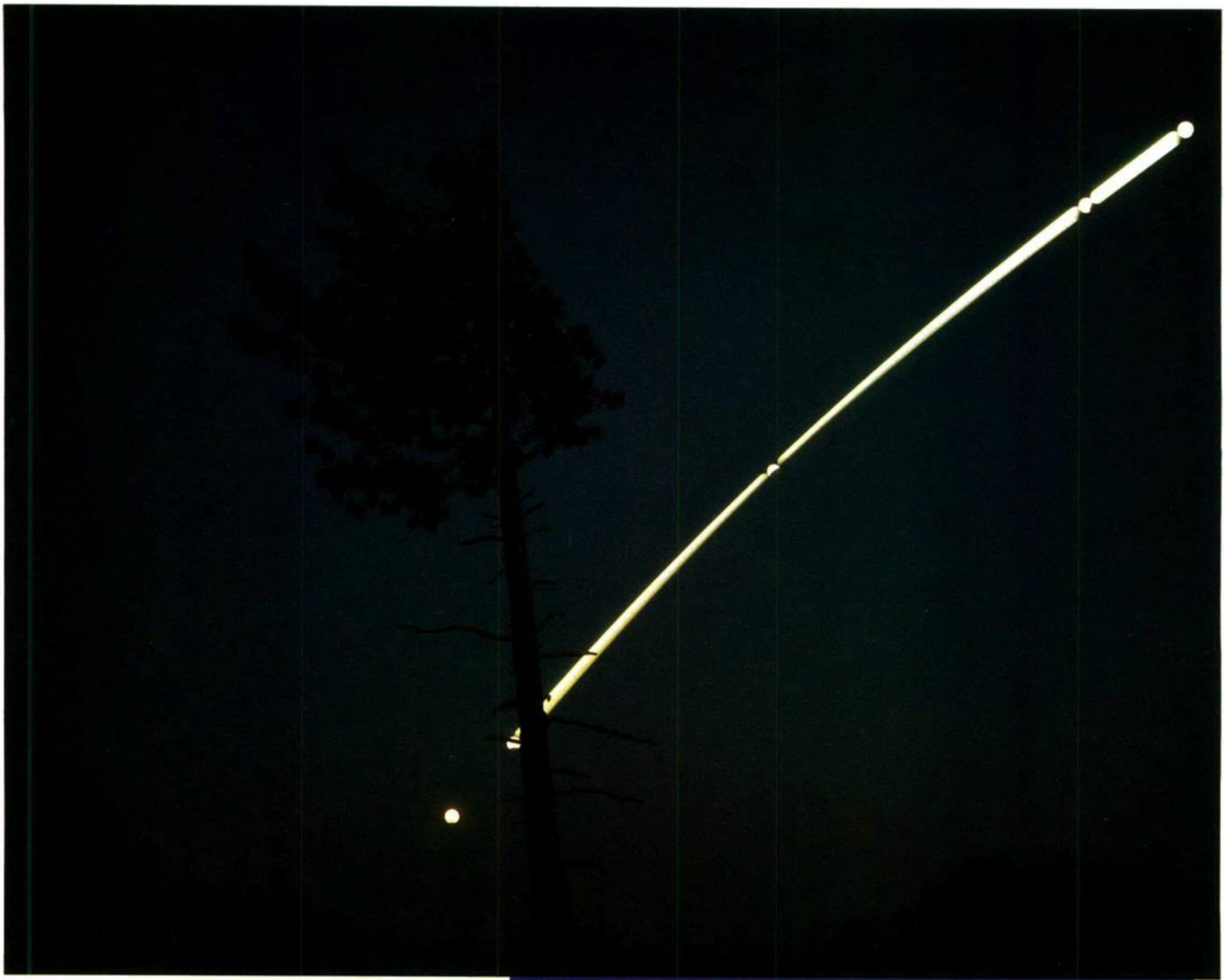
JERRY SCHAD: April 24, 1986, 200mm f/2.8 telephoto, Ektachrome 800/1600 at ISO 800, 2.5 seconds.



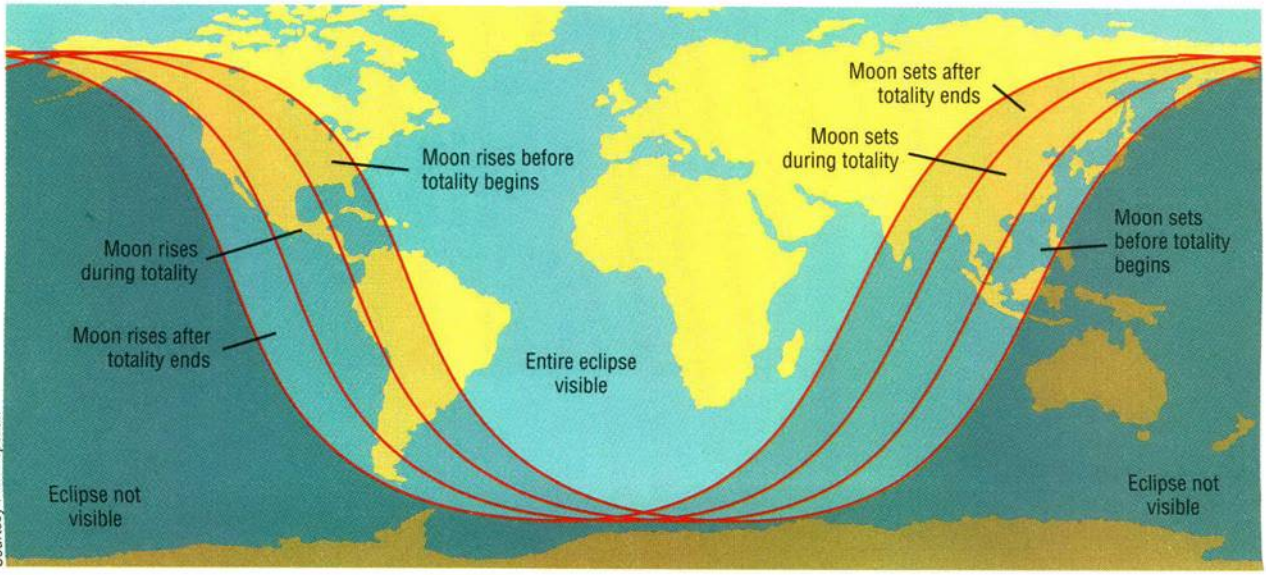
DAVID BREWER: June 14/15, 1992 partial lunar eclipse, video camera and telescope.

The Darkness of Totality

Note the color of the Moon as the partial phases progress. Or more to



RONALD E. ROYER: July 16, 1981, 4x5 camera, 135mm lens at f/90, Ektachrome 64, 2.5-hour exposure with breaks for 2-second shots at f/5.6.


Moon sets after totality ends
Moon sets during totality
Moon rises before totality begins
Moon sets before totality begins
Moon rises during totality
Moon rises after totality ends
Entire eclipse visible
Eclipse not visible
Eclipse not visible

Courtesy Fred Espenak

ECLIPSE PHOTO TIPS

A lunar eclipse is one of the most photogenic of celestial subjects. Unlike total solar eclipses, total eclipses of the Moon happen at a leisurely pace, giving you time to try different exposures, films, and techniques such as:

Telescopic Close-ups (example: Terence Dickinson's photo on page 74). Shooting through a telescope may be a challenge at this eclipse. If, as expected, this eclipse proves to be unusually dark, exposures for the totally eclipsed Moon will need to be long and may not show much color.

To capture a telescopic portrait you will need an equatorial mount that is polar aligned and driven by a motor — recommended equipment for any lunar eclipse. However, for the long exposures needed for this event you will also need a drive that can run at the "lunar" rate, a speed that is about 4 percent slower than the sidereal rate used to track the stars.

Exposures with ISO 1600 or 3200 film (a necessity if this is a dark eclipse) and an f/6 telescope could be as long as 30 to 90 seconds. (With an f/10 Schmidt-Cassegrain scope exposures could stretch to 4 to 6 minutes! To cut exposure times, use a telecompressor to speed up your scope to f/5 or f/6.3.) During exposures of this length, the Moon's orbital motion will cause it to move noticeably against the background stars. If your scope tracks the stars and not the Moon, the Moon will blur.

Tracking on the Moon, however, could net you a unique shot such as Richard Keen's photo of the December 30, 1982 eclipse on page 79. This was also a dark eclipse, coming in the year of El Chichon's eruption.

On the other hand, if the Moon appears bright red at totality you could switch to a finer-grained ISO 400 film and use exposures from 4 to 60 seconds. Whatever happens, take a wide range of exposures.

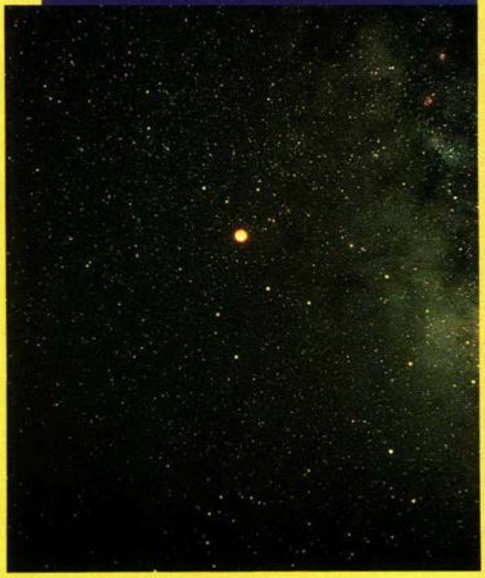
Eclipse TV (example: David Brewer's video frame on page 75). If you're a videophile, simply aim your camcorder into the eyepiece of your scope (use a low-power eyepiece) and let the auto-exposure feature do its job. The camera should expose the bright part of the Moon correctly but the shadowed portion will be too faint for all but the most sensitive cameras.

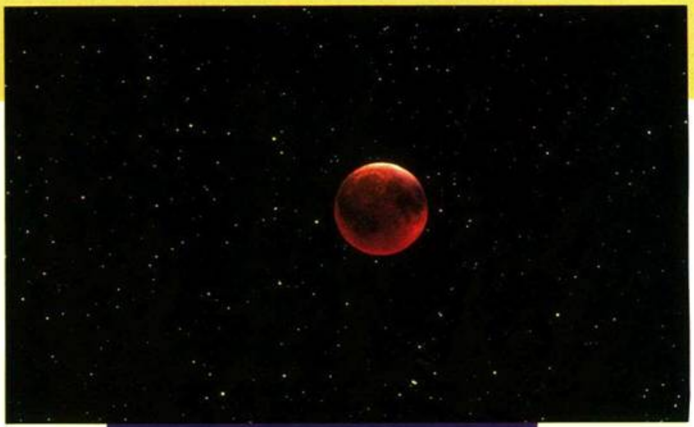
The Rising Moon (example: Jerry Schad's photo on page 75). Use a tripod-mounted camera, a normal lens or short telephoto, ISO 400 to 3200 film, and exposures of 1/8 to 10 seconds at f/2.8.

A Streaking Moon (example: Ronald Royer's photo opposite). Use a tripod-mounted camera, a wide-angle lens set to f/22 or slower, and ISO 64 film. Place the Moon on one side of the frame at the start of the eclipse, open the shutter, and let the motion of the sky streak the Moon across the frame. During the 3.5-hour-long eclipse, the Moon will travel 50° across the sky. For his shot of the

[continued on page 79]

LEE C. COOMBS: July 6, 1982, 50mm f/2 lens, Ektachrome 400 at ISO 800, 10 minutes.





JACQUES GUERTIN: December 30, 1982, 300mm f/1.5 Schmidt camera, Ektachrome 64, 2 minutes.

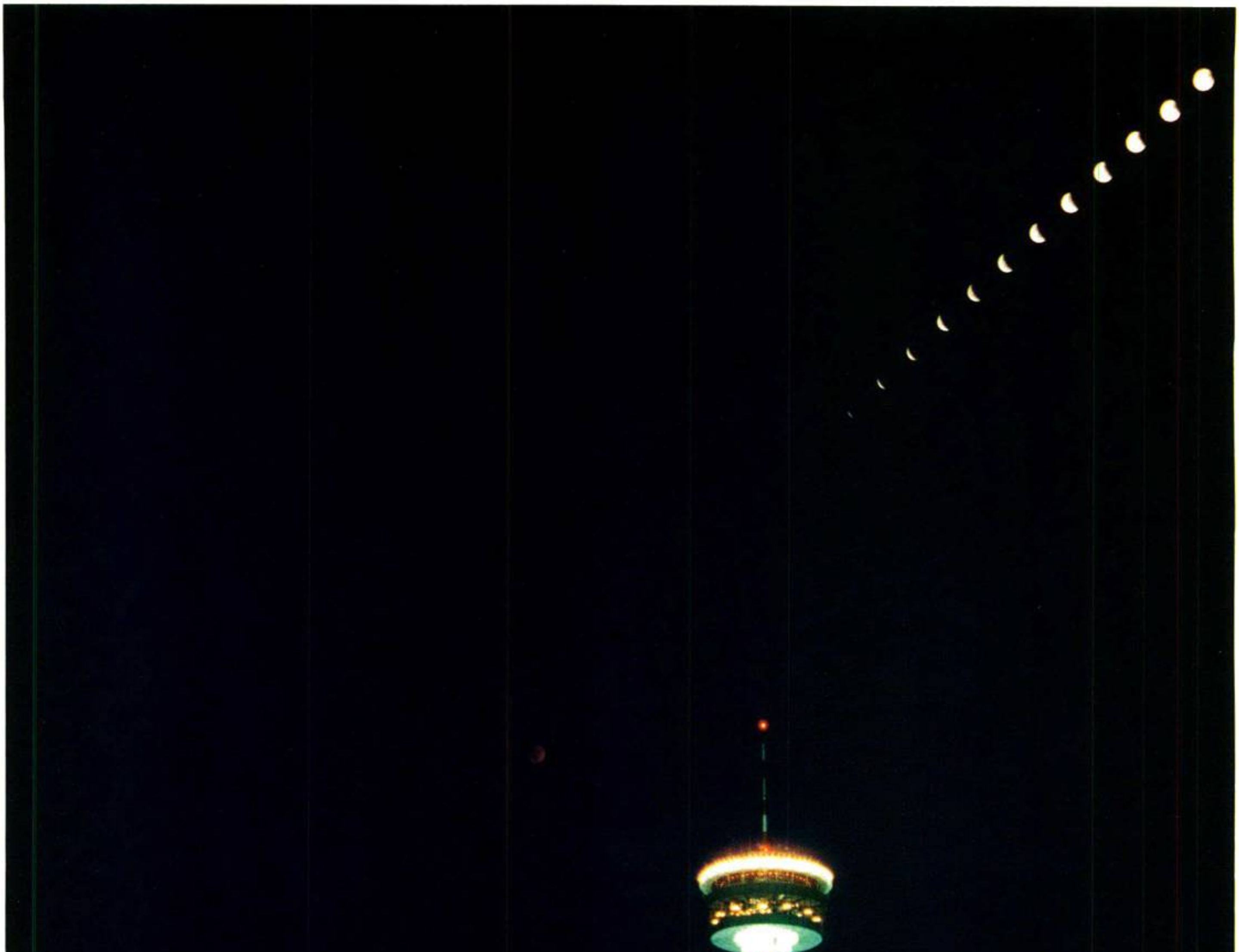
the point, do you see any color on the eclipsed part of the Moon at all? In a typical eclipse, you start to see the orange or reddish hue characteristic of totality during the latter part of the partial phases. If this eclipse is as dark as last June's was, however, you probably won't see any color at all.

At first you might wonder how any light reaches the Moon during an eclipse. After all, if you were on the Moon watching the eclipse, Earth would block the entire disk of the Sun. What happens is that Earth's atmosphere acts like a huge lens and refracts, or bends, the sunlight passing through it, partially filling in the shadow. Red light, with its longer wavelength, makes it through the great thickness of air more easily than sunlight of shorter wavelengths, so Earth's shadow typically appears reddish. (That's also why sunrises and sunsets appear red.)

That's where the 1991 eruption of Mount Pinatubo comes into play. It injected huge amounts of sulfur dioxide aerosols and volcanic ash into the upper atmosphere, where it blocks most of the sunlight that would normally pass through during an eclipse. Unquestionably, the debris from Pinatubo will have dissipated some in the six months since the June eclipse. But there should be enough left to give us a darker than normal eclipse.

We'll know for sure once totality starts at 23h07m UT. Mid-eclipse comes at 23h44m UT, half-way through the 75 minutes of totality that ends at 0h22m UT on December 10. Most everyone in North America will get to see at least part of totality. The only people who won't are those in California, Baja California, southwestern Arizona, western Nevada, and western Oregon.

Though some people on the West Coast will miss totality, they will still catch the concluding partial phases. The Moon leaves Earth's umbra at 1h29m UT, well after the Moon has risen everywhere in North America. Although only a few die-hard eclipse viewers will watch the final penumbral phase of the eclipse, that



ROBERT REEVES AND RON DAWES: August 16, 1989, 35mm lens, Kodacolor 100, *partial phases* at 1/60-second at f/5.6 and f/8, mid-totality at 20 seconds, exposures made at 5-minute intervals.

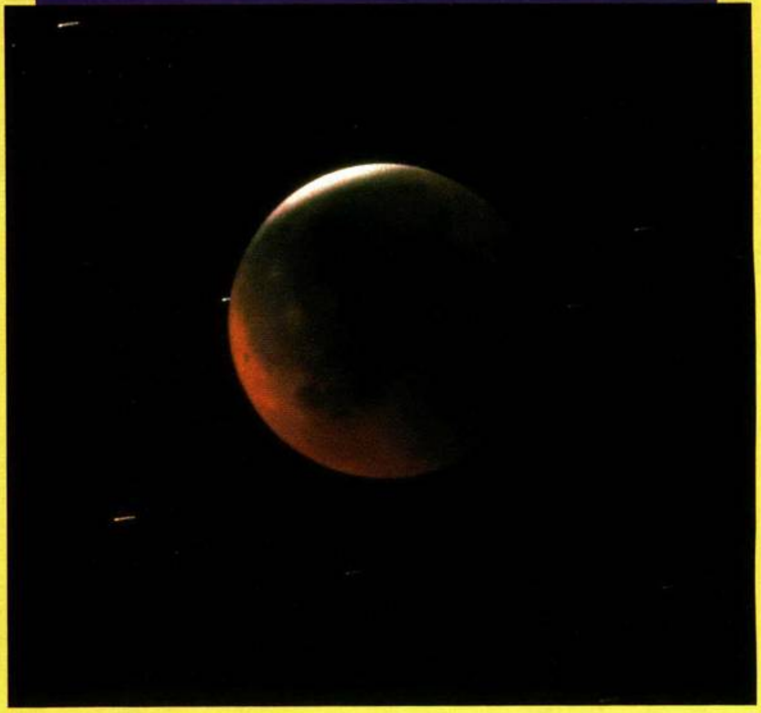
July 16, 1981 partial eclipse, Royer punctuated the long streak with several 2-second exposures at f/5.6, a creative variation.

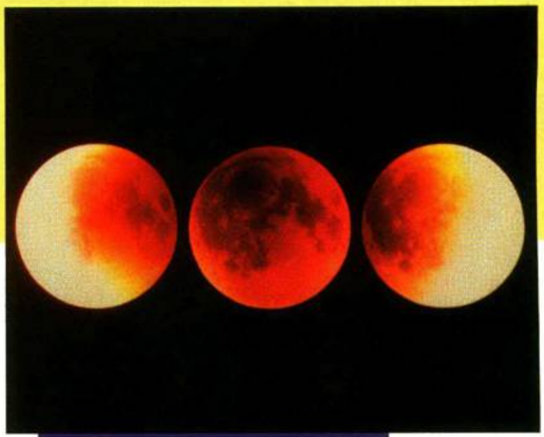
Multiple Magic (example: Robert Reeves' and Ron Dawes' shot opposite). Take exposures every 5 or 10 minutes *on a single frame* of ISO 400 film. Use exposures of about 1/125 second at f/8 for the first half of the partial eclipse then descend in steps until you reach 2 seconds or so at the start of totality. Lengthen the exposures during totality to a maximum of 20 seconds at mid-eclipse (opening to f/4 or f/2.8 if the Moon is dark). Use the same sequence of exposures after mid-eclipse as you did leading up to it.

Piggyback Portraits (examples: Lee Coombs' and Jacques Guertin's shots on page 77). The Moon will be near the winter Milky Way during this eclipse, making for attractive piggyback deep-sky photos. You'll need an equatorially mounted clock-driven telescope. Mount your camera to the side of the tube and use the scope as a guiding platform. Use ISO 200 to 400 film, a normal or telephoto lens, and exposures of 2 to 10 minutes at f/2.8. If the Moon is extremely dark, this may be the only way to record it well.

Triple Play (example: Jim Rouse's photo on this page). This clever technique reveals the outline of Earth's shadow. You need to shoot through a 600mm- to 1000mm-focal-length telescope or telephoto. This yields a field of 2° to 4°. The scope or lens must be driven but tracking the stars, not the Moon. Place the Moon near the *west* side of the frame. The Moon will drift east across the frame during the eclipse. Take an exposure an hour before mid-eclipse, then *without advancing the film* take a second shot at mid-eclipse, then a third on the same frame an hour after mid-eclipse. These intervals will prevent the three Moon images from overlapping. The first and third shots will fall when the Moon is 65 percent eclipsed. Because exposures for the shadowed part of the Moon will be unpredictable, for the two partial phase shots it might be best to expose for the bright portion instead. To do this use an exposure of 1/250 second (assuming f/8 with ISO 1600 film). The single exposure for mid-eclipse will require a seat-of-the-pants judgement based on how dark the Moon appears.

RICHARD KEEN: December 30, 1982, 6-inch f/5 reflector tracked on the Moon, Ektachrome 400, 3 minutes.





JIM ROUSE: August 16, 1989, 4-inch f/9 refractor, Ektachrome 400, 30 seconds for each.

will continue until last contact at 2h33m UT.

On the other side of the globe, all of Europe and Africa will see all phases of the eclipse. People in western Asia will see the entire eclipse, but with the latter stages edging toward the time the Moon sets on the morning of the 10th. From eastern Asia, the Moon sets during the eclipse. Only those people in Australia, New Zealand, and some islands in the Pacific miss out on seeing any of the eclipse.

Pinpointing the Moon

Several factors will conspire to make the Moon difficult to spot from much of the Americas during the eclipse's early stages. First, the Moon rises during the partial or total phases; second, because the Moon rises at sunset, bright twilight will interfere until the Moon climbs higher in the sky; and third, the eclipse may be unusually dark. If you want to view the eclipse as soon as it starts, you'll need to know where the Moon will be when it rises. For an observer at 40° north latitude, look about 30° north of due east. From 25° north latitude, the Moon comes up about 25° north of east.

You can avoid measuring these angles if you watch the Moon rise a night or two before the eclipse. Because the Moon is near the northern limit of its monthly path around Earth, its position as it rises changes little from one night to the next. On the evening of the eclipse, the Moon rises just 1° south of where it rises on the 8th and about 4° south of its position on the 7th, regardless of your latitude.

Another reason to plan ahead is that the eclipse starts just as many people arrive home from work or school. Waiting until the evening of the 9th to figure out where to look could be a prescription for missing totality.

More than likely, however, if you miss totality it will be because of bad weather. No prescription will cure that, just time and patience. But at least it won't be a long wait this time. Two total lunar eclipses will grace our skies next year — one on the morning of June 4 visible from the West Coast and one on the night of November 28/29 with all phases visible from all of North America. By then the Moon may well exhibit its more traditional eclipse colors, so barring more volcanic eruptions, this could be your last chance for a while to view an unusual, dark eclipse. □

Exploring the Winter Sky

Despite the chill associated with winter, now is the time to enjoy the magnificent sparkling stars of the brilliant winter Milky Way.

by Deborah Byrd

Winter calls to mind crisp, clear nights and diamond-bright stars. Whether our winters are bitterly cold or relatively mild, we can all look up at this time of year to see a classically beautiful night sky. The many brilliant stars in the evening sky in this season come in an array of colors, and they form striking patterns that are easy to identify and recall. Later, when the mind and soul are refreshed after an evening out under the stars, it will feel good to open a door and step inside to the warmth of home again. But while the winter stars shine overhead, you have reason to reflect on a larger meaning of the word *home*. Our home in the universe is partly revealed to those who gaze upward now.

But before contemplating our place in space, look westward in early evening for a reminder of last summer and every summer. The Summer Triangle lies low in the west as the sky grows dark. This isn't a constellation; instead, it's an asterism, or recognizable pattern of stars.

This pattern is made of three bright stars in three different constellations. The brightest is Vega, in the constellation Lyra the Harp. It shines at magnitude 0.0 with a bluish color. Its distance is about 25 light-years. The next-brightest star in the Summer Triangle is Altair, in the constellation Aquila the Eagle. This star shines at magnitude 0.8 from a distance of about 16 light-years. The third triangle star is Deneb, which is the faintest

CANIS MAJOR contains the brightest star in the sky, Sirius, and the prominent open cluster M41.

Henry Nebel

of the three triangle stars at magnitude 1.3. At a distance of 1,600 light-years, Deneb is much farther away than Vega or Altair. Deneb is the brightest star in the constellation Cygnus the Swan, which the ancients imagined with its wings stretched wide, flying along the starlit trail of the northern Milky Way. A more modern asterism made from these same stars is the Northern Cross. Deneb marks the tail of the Swan — and the top of the Cross, a pattern which stands nearly upright in the west in the evening now.

Now turn toward the southwest for a last look at one of autumn's brightest lights, Fomalhaut. Sometimes called "the loneliest star," this is easily the brightest star in the constellation Piscis Austrinus, the Southern Fish. It shines at magnitude 1.2 from a distance of 22 light-years. Two zodiacal constellations, Capricornus the Sea Goat and Aquarius the Water Carrier, can be found north of Fomalhaut. Capricornus is shaped like an arrowhead. Aquarius is large, faint and generally formless, but in a dark sky you can see its compact Y-shaped asterism called the Water Jar. A faint stream of stars zigzags from the Water Jar toward Fomalhaut.

A large, conspicuous asterism is located just west of the zenith in early evening now. This is the Great Square within the constellation Pegasus the Flying Horse. Four fairly bright stars mark the corners of the Square, which represents the horse's body. You can test your vision and the night's conditions by counting the number of stars you see in the Great Square.

The star in the northeast corner of the Square, Alpheratz, is really Alpha Andromedae, part of the constellation of the Chained Maiden that extends northeastward from the Square. Within this constellation's boundaries is one of the most amazing objects accessible to our vision, the Andromeda Galaxy. On a moonless night, in a dark country sky, the Andromeda Galaxy appears as a hazy oval patch. It's really a separate island of hundreds of billions of stars, slowly spinning majestically across a distance of 2.2 million light-years. As you stand gazing at it with the eye or with binoculars, try to imagine how any hypothetical beings in that distant galaxy might see our Milky Way.

Now sweep with your binoculars southeast of Andromeda for a glimpse of yet another galaxy, M33 in the constellation Triangulum. This galaxy has a low surface brightness, so you'll need an absolutely clear, dark sky to spot it. Both M33 and the Andromeda Galaxy are members of the Local Group, the cluster of a couple of dozen galaxies to which our Milky Way belongs. A beam of light would take some 100,000 years to travel across a galaxy like M33. Meanwhile, the entire Local Group occupies a region of space several million light-years across.

James Bailey

ORION THE HUNTER is instantly recognizable on winter evenings. Its brightest stars are blue-white Rigel (bottom right) and orange Betelgeuse (top left).

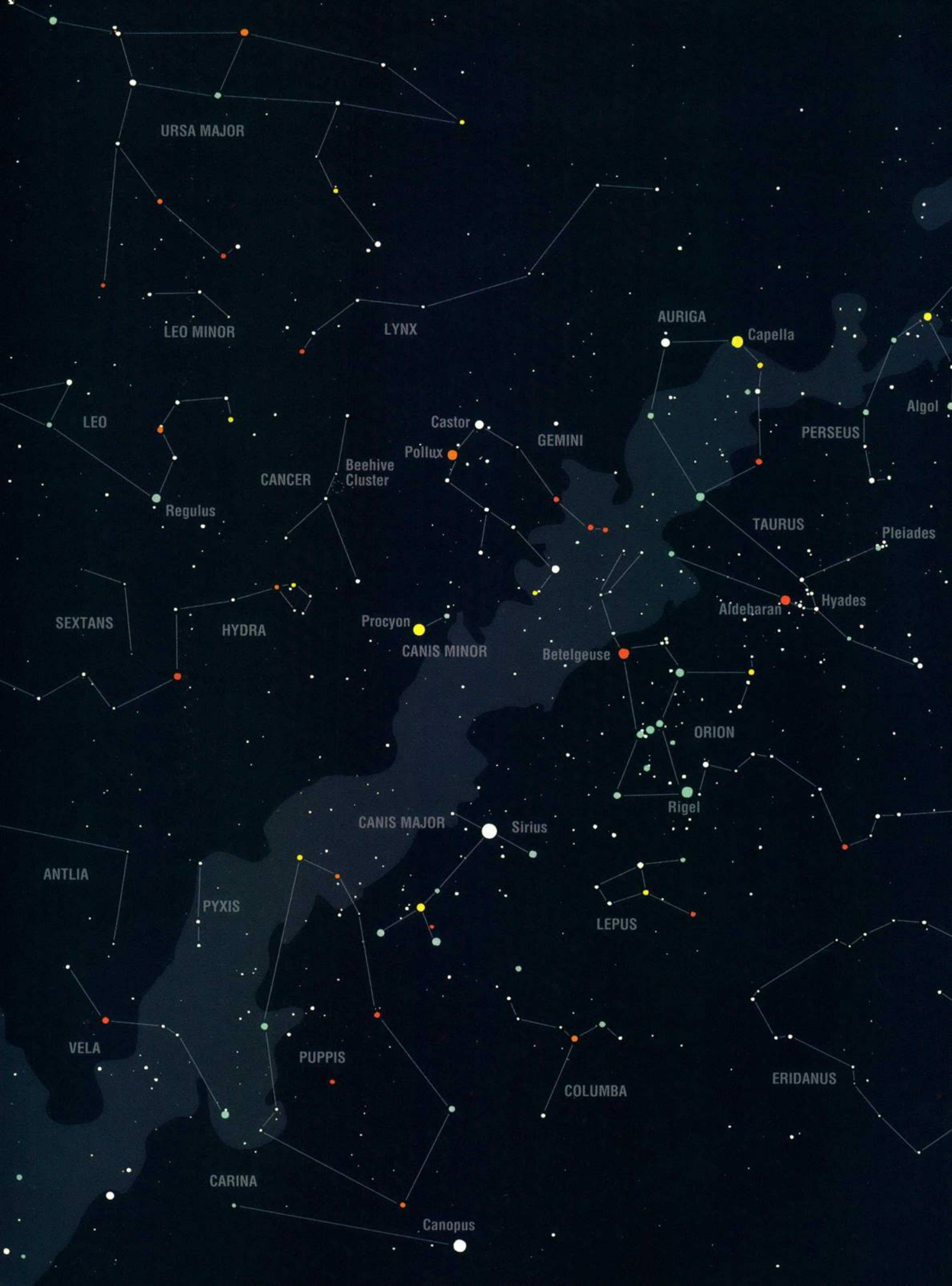
Immediately south of Triangulum is the zodiacal constellation Aries the Ram. Its three primary stars shine no more brightly than 2nd magnitude, but the short, crooked line formed by these stars is easy enough to find. A fainter and much larger zodiacal constellation is Pisces the Fish. Its two faint graceful streams of stars run along the south and east sides of the Great Square. They are sometimes called the Northern and Southern Fish. Another "watery" constellation is Cetus the Whale, whose most famous star sometimes cannot be seen with the eye. Mira, or Omicron Ceti, brightens and fades between 3rd and 10th magnitude on a timescale of about a year. It is located about 200 light-years away. Diphda, sometimes called Deneb Kaitos, is the brightest star in Cetus. From Diphda, you can follow the Whale's long neck northward to the Head of Cetus. Cetus is a dreaded monster in mythology, but this circlet head atop a skinny neck of stars makes the Whale look funny and friendly instead.

If you're near the southern border of the United States on a winter evening, you might glimpse a bright star even lower in the south than Cetus. This is the ninth-brightest star in the sky, but it's so far south on the celestial sphere that it makes only a tiny arc across the Northern Hemisphere sky. This star is Achernar, "the End of the River," in the constellation Eridanus. Your first glimpse of it may mark the beginning of a yearning to visit the Southern Hemisphere. Look for the source of the River, a star called Cursa, located near the star Rigel in the constellation Orion. From its source near Orion, the River wells up in a great loop before meandering southward.

ORION'S SWORD contains the brightest nebula visible from the Northern Hemisphere, the Orion Nebula. It appears as a fuzzy patch of mist to the naked eye.

Jim Curry

So far we've been looking in the western and southern parts of the sky. Now it's time to face east, toward winter's brightest stars. The Winter


URSA MAJOR
LEO MINOR
LYNX
AURIGA
Capella
LEO
Castor
GEMINI
Algol
PERSEUS
Pollux
CANCER
Beehive Cluster
Regulus
TAURUS
Pleiades
SEXTANS
HYDRA
Procyon
Hyades
Aldebaran
CANIS MINOR
Betelgeuse
ORION
Rigel
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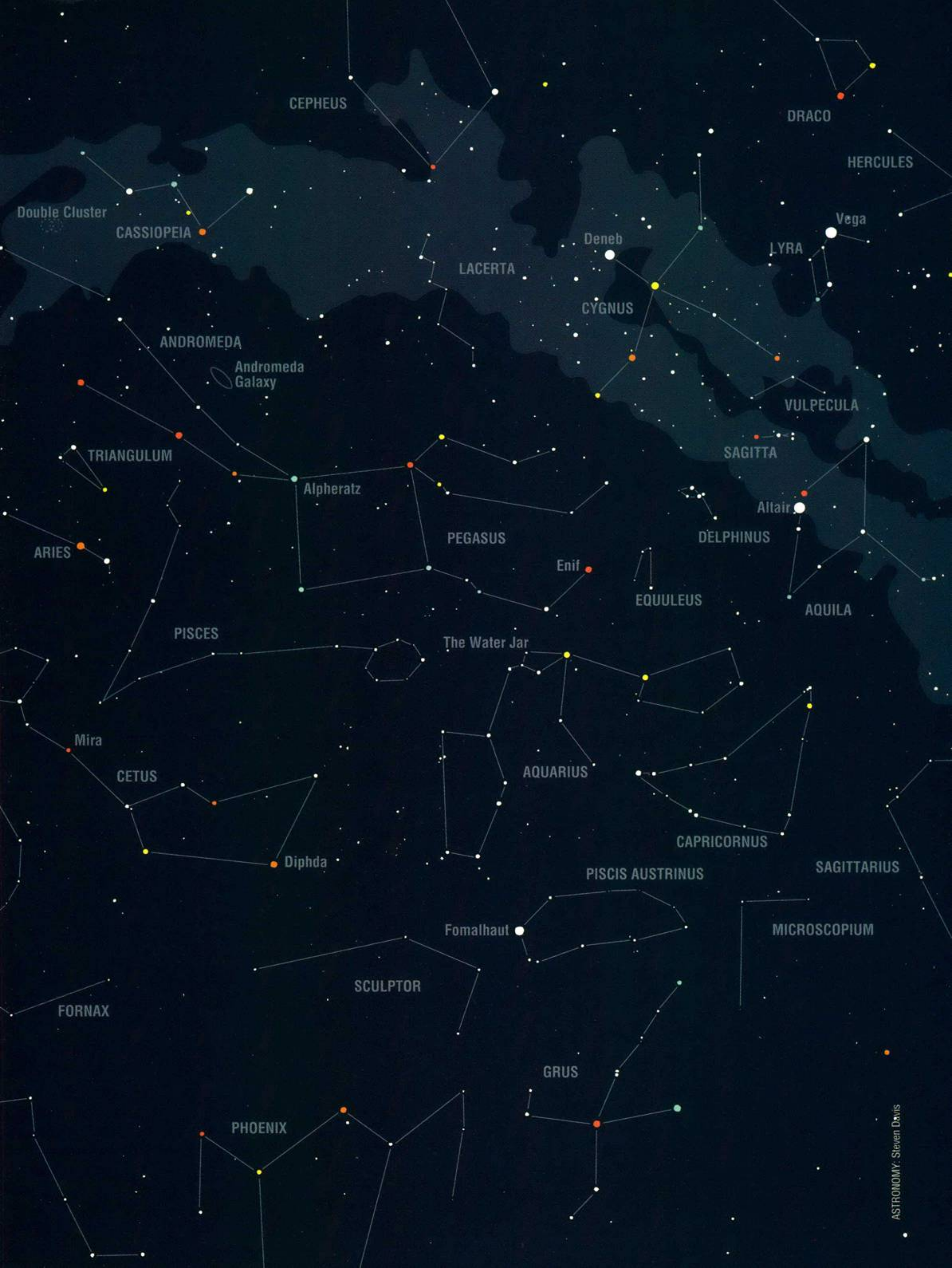
COLUMBA
ERIDANUS
CARINA
Canopus


CEPHEUS
DRACO
HERCULES
Double Cluster
CASSIOPEIA
Vega
Deneb
LYRA
LACERTA
CYGNUS
ANDROMEDA
Andromeda Galaxy
VULPECULA
SAGITTA
TRIANGULUM
Alpheratz
Altair
PEGASUS
DELPHINUS
ARIES
Enif
EQUULEUS
AQUILA
PISCES
The Water Jar
Mira
CETUS
AQUARIUS
CAPRICORNUS
Diphda
PISCIS AUSTRINUS
SAGITTARIUS
Fomalhaut
MICROSCOPIUM
SCULPTOR
FORNAX
GRUS
PHOENIX

ASTRONOMY: Steven Davis

Circle is ascending in the east each evening now. This large asterism consists of bright stars in several different constellations, including Rigel and Betelgeuse in Orion, Sirius in the constellation Canis Major, Procyon in Canis Minor, Castor and Pollux in Gemini, Aldebaran in Taurus, and Capella in Auriga. Don't worry about identifying these stars separately at first. Instead, notice the contrast in their colors. Astronomers categorize stars according to their colors (or temperatures), and the Winter Circle stars represent nearly all the different categories.

L. H. Price

THE WINTER MILKY WAY cascades through Cassiopeia's bright stars and star clusters. This area is magnificent when viewed with binoculars.

When you do start to look for separate stars and constellations, your eye will probably go first to the distinctive pattern made by the constellation Orion. This constellation contains a short straight row of three medium-bright stars known as Orion's Belt. Alnitak, Alnilam, and Mintaka (east to west) do not shine as brightly as some other winter stars because they are exceedingly distant at about 1,400 light-years away. They're relatively young, massive stars destined to squander their thermonuclear fuel and die at a much younger age than our Sun. Orion's two brightest stars are Betelgeuse and Rigel, which lie on either side of the Belt. They are gigantic stars that lie about the same distance away as the Belt stars. Rigel, at magnitude 0.1, appears a little brighter than Betelgeuse. It marks the left foot of the Hunter, while Betelgeuse is the Hunter's right shoulder.

This is a good place to start learning to be at home in our Milky Way Galaxy. It's easy to gaze at the three Belt stars, and at Betelgeuse and Rigel, and imagine them as giants moving among lesser stars. Like our Sun, these stars move on vast orbits that carry them around the galactic center every few hundred million years.

AURIGA THE CHARIOTEER lies in the thick of the winter Milky Way and holds several bright star clusters. Its brightest star is yellow-orange Capella.

Kenneth Paul Fye

When we gaze toward these and the other bright stars of winter, we're looking edgewise into the disk of our own Galaxy. We did the same thing last summer when the hazy band of the Milky Way ran like a starry river across the sky. But tonight the Milky Way appears thinner and sparser. This is because instead of facing the center of our home Galaxy, we're looking out toward the more sparsely populated galactic edge.

Gazing toward Orion we see the spiral arm of the Galaxy to which our Sun belongs. That's why so many bright stars crowd overhead in this season. Our local spiral arm is sometimes called the Orion Arm, but ancient stargazers knew nothing of this. To them Orion was the mighty Hunter, a heroic figure striding among the stars, a source of legends that added richness to the pattern of people's lives thousands of years ago. Our ancestors identified the Sword of Orion hanging from the Belt. No doubt they knew that one of the stars in the Sword looks distinctly hazy. Binoculars aimed in this direction will reveal the famous Orion Nebula, a cloud of hydrogen gas made to glow by the energy of youthful stars. We know the Orion Nebula as the luminous tip of a vast "iceberg" of gas and dust. Thousands of new stars may eventually emerge from this region of star formation.

Now go back to Orion's Belt. An imaginary line drawn westward through the Belt points to the bright star Aldebaran, the fiery red eye of the Bull in the constellation Taurus. The V-shaped pattern of stars to which Aldebaran appears to belong is called the Hyades. It's not just a pattern on the sky's dome. It's an actual open star cluster whose stars were born around the same time from a cloud of gas and dust. Aldebaran is not a true member of the Hyades cluster. It merely lies along our line of sight to the cluster, about halfway between us and it, roughly 60 light-years away.

Another star cluster in Taurus, this time marking the shoulder of the Bull, is the Pleiades, or Seven Sisters. This little dipper of stars is one of the most famous sights in the sky. It looks even more like a dipper than the real Little Dipper asterism — part of the constellation Ursa Minor — located in the northern sky. Some observers claim to see seven or more stars in the Pleiades, but many people say they see only six. There are legends of a "lost Pleiad," said to have given up her place among the stars after marrying a mortal. The Pleiades sometimes appears veiled in mist. If you peer at it through your binoculars, it'll capture your heart forever.

Now extend an imaginary line in the opposite direction, eastward from from Orion's Belt. You will soon find the sky's brightest star, Sirius, in the constellation Canis Major the Greater Dog. This star shines at magnitude –1.5 and is sometimes called the Dog Star. Sirius was important to early Egyptian skywatchers. When it reappeared in the morning sky during the summer months after passing behind the Sun, they knew the time was drawing near for the annual flooding of the Nile.

Today, we know Sirius as a blue-white main-sequence star in a stage of its evolution not unlike that of our Sun. It is an intrinsically brighter star than the Sun, but its brightness in our sky stems mainly from its proximity. It is one of the nearest stars, about nine light-years away. The name *Sirius* comes from a Greek word meaning "hot" or "scorching." New stargazers sometimes are startled to notice this star flashing different colors. The effect is so unexpected that Sirius is often reported as a UFO. But the rapid twinkling of Sirius and its glittering colors stem from the most earthly of reasons. Because Sirius is low in the sky from the Northern Hemisphere, we typically see it through a thick layer of atmosphere. Be sure to look just below Sirius for M41, an open star cluster more distant than the Pleiades or Hyades. It is visible to the eye under excellent conditions and can be seen easily in binoculars.

The star Procyon is located northeast of Sirius. Its name means "before the dog," which refers to the fact that it rises shortly before Sirius. At magnitude 0.4 Procyon is the brightest star in its own tiny constellation, Canis Minor the Lesser Dog. It is a nearby star, lying only about 11 light-years away.

If you continue northward, you'll come to two stars that are conspicuous for their brightness and apparent nearness to each other. They are only about five degrees apart on the sky's dome. Castor and Pollux represent the starry eyes of the Twins in the constellation Gemini. Pollux is the brighter star at magnitude 1.1. It is 35 light-years away. Lying north of Pollux, Castor is fainter and slightly more distant at 49 light-years away. Although it is a multiple star system, Castor appears single to the naked eye and in binoculars. The single point of light we see as Castor is really six stars, all moving around each other in an intricate cosmic dance. The rest of the constellation Gemini goes southward in two streams of stars, extending into the midst of the winter Milky Way.

Ed Barnes

GEMINI THE TWINS is a bright, rectangular group of stars that contains the bright stars Castor and Pollux.

Continue northwestward. You will come to Capella, the brightest star in the constellation Auriga the Charioteer. Capella falls into the same star color or temperature category as our Sun. Capella shines at magnitude 0.1 from a distance of 41 light-years. It is sometimes called the Goat Star. If you look near Capella, you'll notice a little asterism in the shape of a triangle. This asterism is called the Kids. The rest of the constellation Auriga is a five-sided figure situated in the midst of the winter Milky Way. You'll find the open star clusters M36, M37, and M38 in Auriga, if you sweep with your binoculars.

Some other patterns you shouldn't miss lie in the winter sky. The graceful constellation Perseus lies northwest of Auriga. It represents a hero in ancient mythology, but has always reminded me of someone dancing. Don't fail to turn your binoculars on the Double Cluster in Perseus.

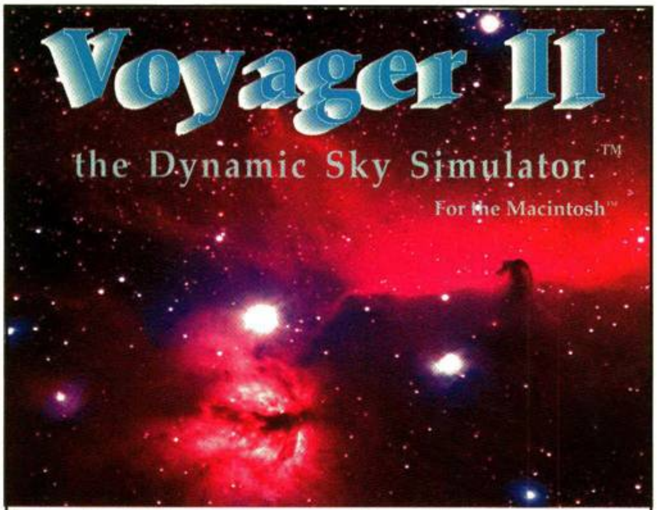
Also, if you live far enough south you will come to know another bright star each winter. This star is located even farther south on the celestial sphere. It is Canopus in the constellation Carina the Keel. This star cannot be seen from the northern United States, but from the southern United States it's much easier to see than Achernar, described above. Canopus is the sky's second-brightest star. It's another symbol of the wonders hidden by the bulk of the Earth beyond the southern horizon.

CANIS MINOR holds the bright white star Procyon in its relatively small area of sky.

Daniel J. McGlaun, Jr.

Finally, look in the east for a constellation so inconspicuous you may need binoculars just to locate it. This is the zodiacal constellation Cancer the Crab. A sweep with binoculars will reveal the large Beehive star cluster, also called Praesepe. Hot on the heels of Cancer in its ascent into the eastern sky is Leo the Lion — a constellation that foretells the coming of spring! □

Deborah Byrd writes ASTRONOMY*'s monthly sky column Eye on the Sky. Her last feature article was "Exploring the Autumn Sky" in the September 1992 issue.*



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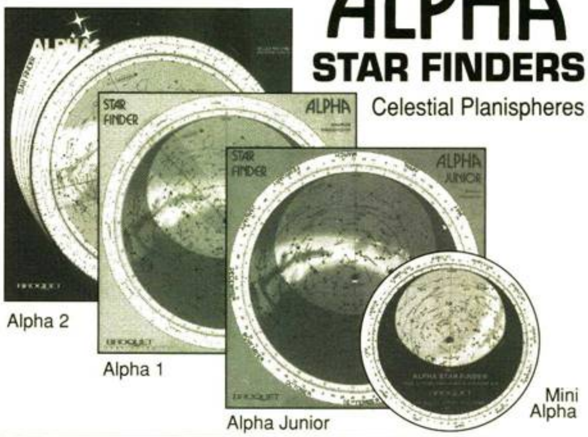

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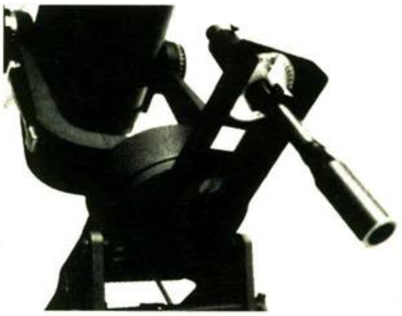

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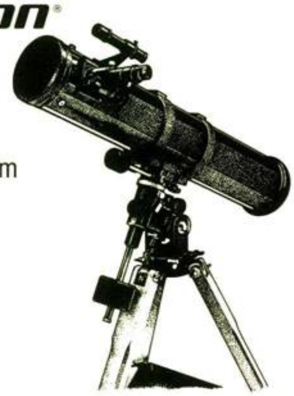

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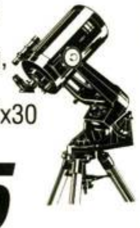

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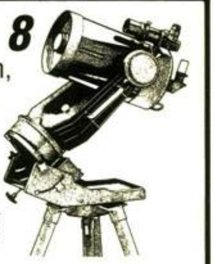

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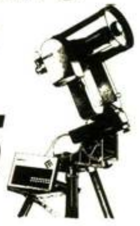

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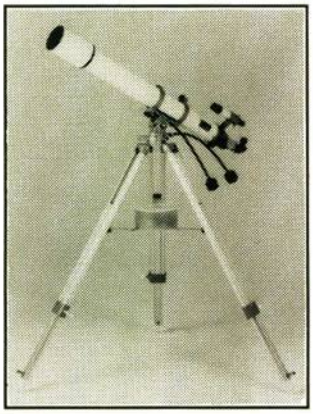

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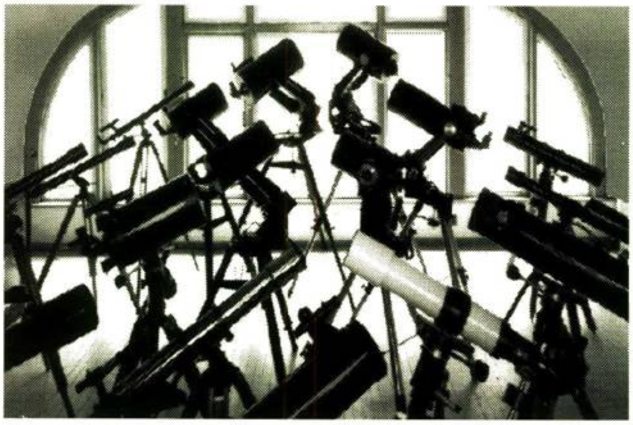

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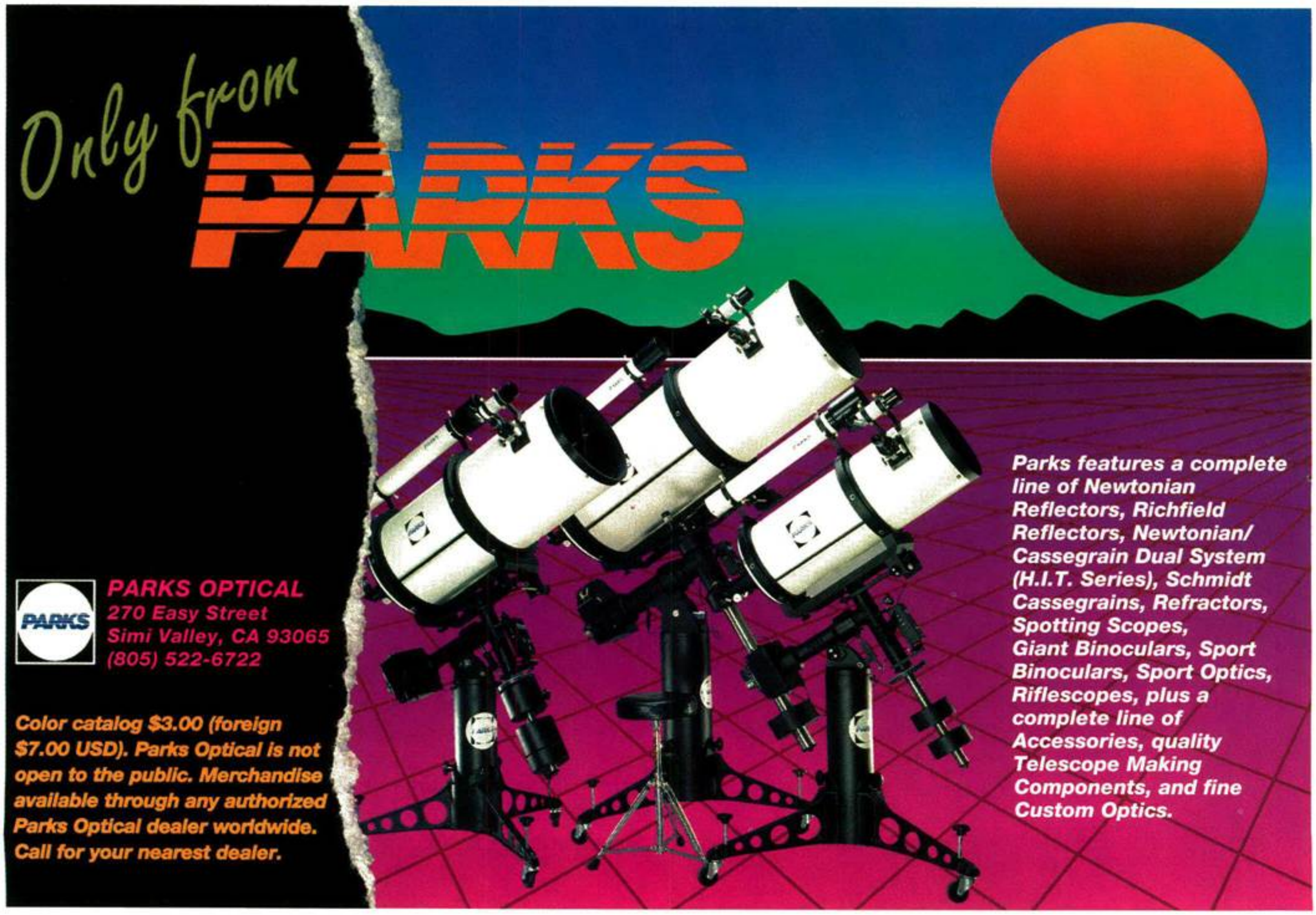

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SUMMERTIME COMET OBSERVING

Comet Shoemaker-Levy (1991a_1) had a good summer. After its October 6, 1991 discovery by professional astronomers Eugene and Carolyn Shoemaker and David H. Levy, who used the 18-inch Schmidt camera at Palomar Observatory, the comet slowly rose in brightness. By June 1992 the comet had brightened to 10th magnitude and lay near the bright stars of Cassiopeia. Throughout June and July, Shoemaker-Levy arced its way across the northern sky, putting on a memorable show for observers equipped with telescopes and binoculars. By August 1 the comet reached Coma Berenices and was low in the evening sky. The comet's brightness and shape on each summer night were recorded in the observing journals of many amateur astronomers across the world.

Richard Didick of Rehoboth, Massachusetts, kept one such journal. Equipped with a 4.5-inch f/8 Newtonian reflector, Didick routinely noted the comet's appearance on each clear night during the prime observing window of June and July. Didick's first observation on June 11 began unceremoniously. "After searching the area at 50x for about 25 minutes, I was finally able to see a dim glow that appeared diffuse," he says. At this time Comet Shoemaker-Levy glowed at magnitude 9.1, according to the skilled comet observer John E. Bortle, of Stormville, New York. Two nights later Didick found the comet "difficult to spot because it lay in a dense field of faint stars," but he was able to confirm the comet's fuzzy appearance at 100x. By June 23, when the comet had brightened to 8th magnitude, Didick was able to spot a fan-shaped coma surrounding a condensed, bright nucleus.

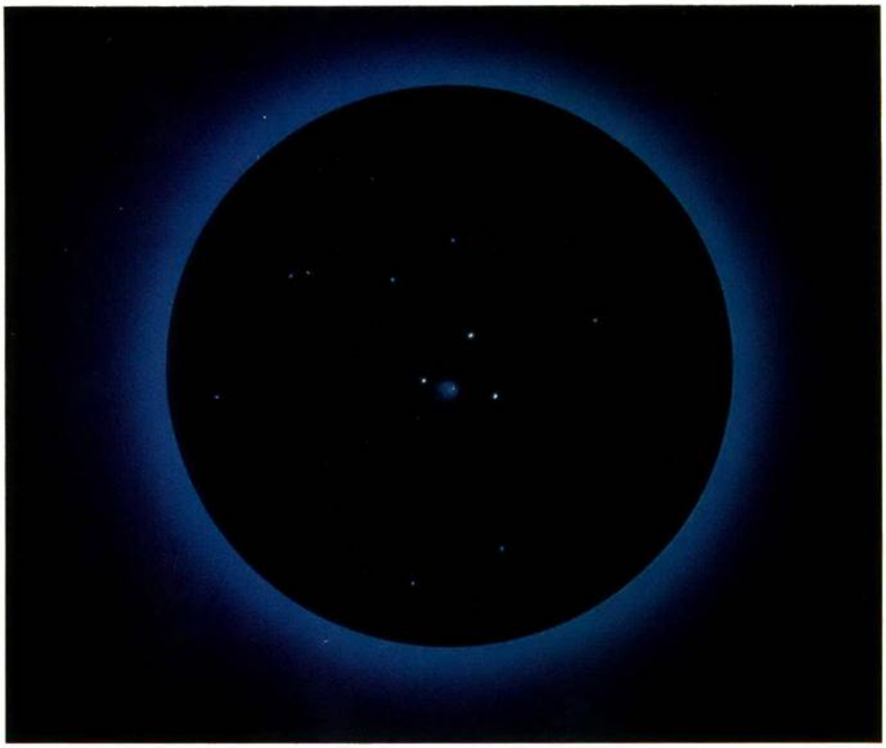
July was the swan song month for Comet Shoemaker-Levy. On July 2 Bortle, using a pair of 10x50 binoculars, reported the comet's magnitude as 7.9. One night later Didick observed the comet twice, the first time noting a bright central condensation around the nucleus and two progressively fainter shells of coma surrounding it, making a "three-layered coma." Didick described a "faint and fleeting outer edge" that increased sharply in brightness toward the center of the comet. Didick returned to the eyepiece 2 1/2 hours later and recorded that the motion of the comet during that interval was significant.

As Shoemaker-Levy passed through the bowl of the Big Dipper on July 11, Didick recorded an unusual observation. Between 9:58 and 10:08 p.m. EDT, the comet's coma grazed a magnitude 8.5 star. "The star blinked out three times during this 10-minute period," says Didick. "I had to wonder if this could be caused by blind spots in my eye or poor seeing conditions."

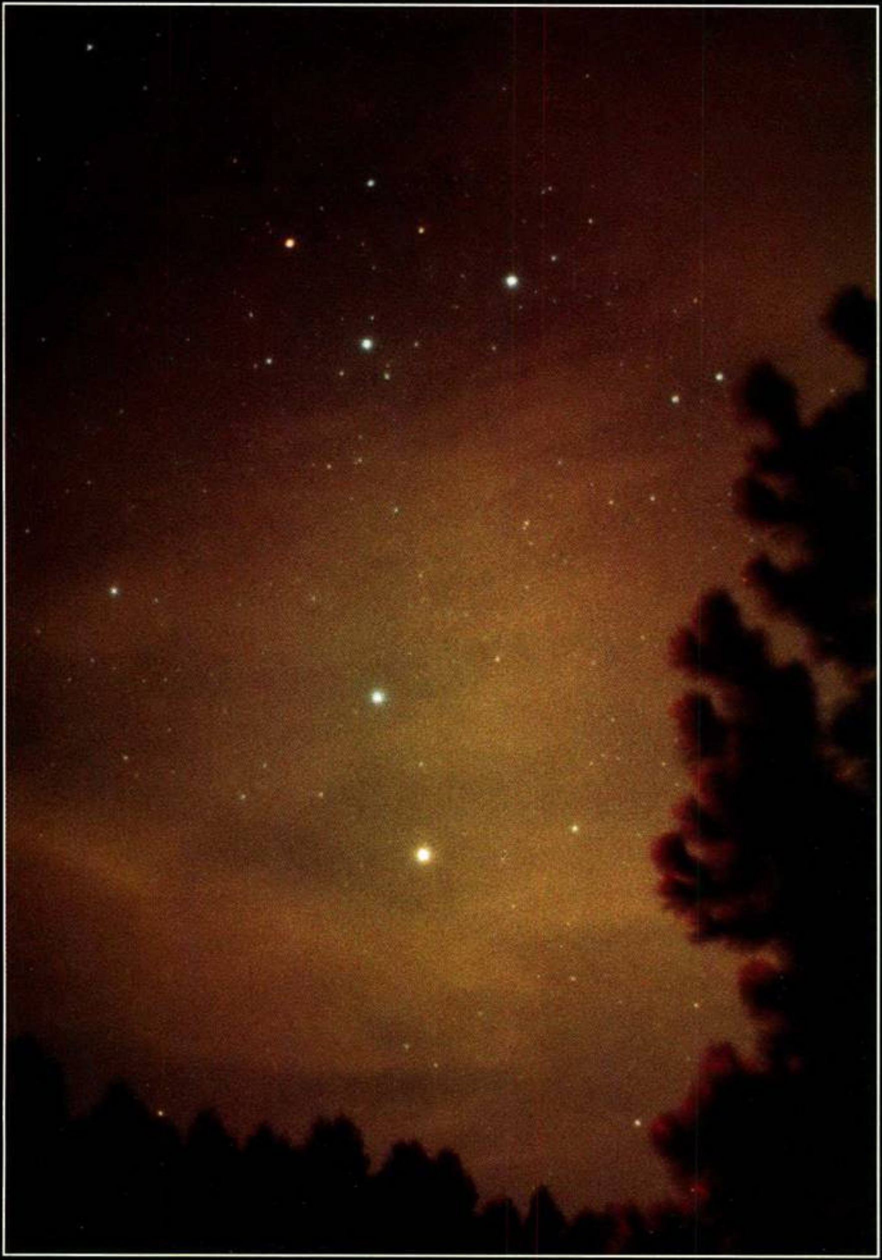
On July 17 the comet glowed at its peak magnitude of 7.2 and displayed a faint tail about 10' long in position angle 45°. "I observed a small, nearly stellar nucleus surrounded by a diffuse inner coma, which in turn lay inside a faint, outer envelope of nebulosity," says Didick. "The inner coma appeared fan-shaped and I suspected seeing a very faint tail."

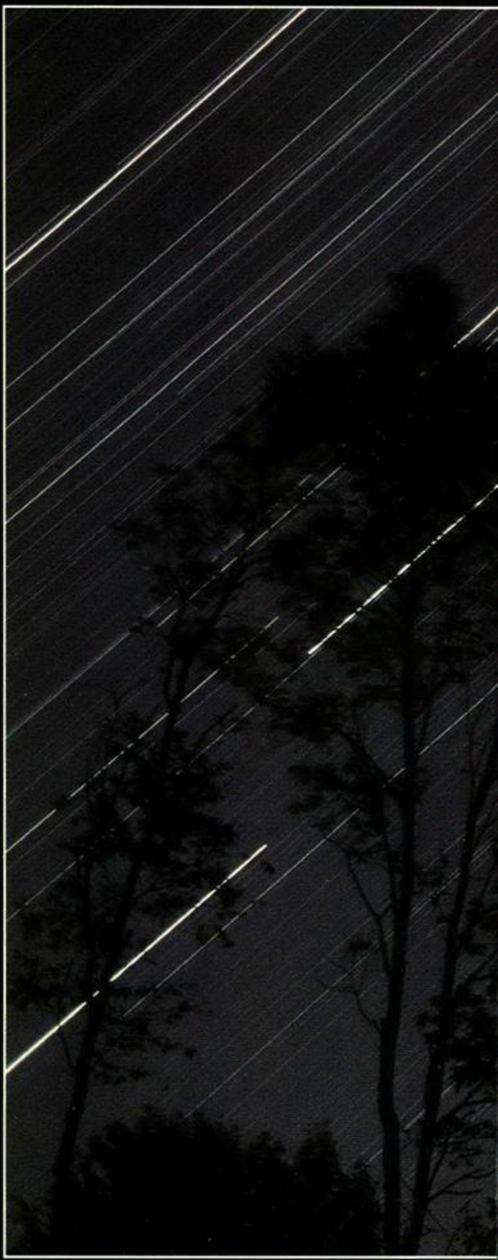
By mid-August Comet Shoemaker-Levy slinked down into the constellation Virgo very low in the western evening sky. The comet faded to magnitude 8 and lost its bedraggled tail. The summer show was over, but Shoemaker-Levy put on a good performance while it lasted. ☐

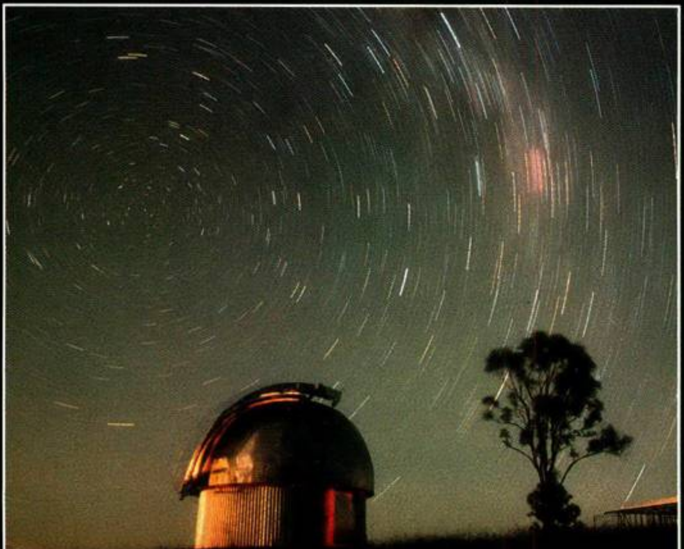
ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187.



COMET SHOEMAKER-LEVY (1991a_1) glowed brightly in the eyepieces of backyard telescopes last summer. On July 28 Edwin Faughn of Memphis, Tennessee, sketched the comet using his 10-inch reflector at 90x (above). Jeffrey Jones' photo (top) shows Shoemaker-Levy on the same night.







HAPPY TRAILS TO YOU

Jim Fantozzi's photograph of the constellation Orion streaking through a treeline (top right) captures this month's $100 Best Astrophoto award. Fantozzi used a 50mm lens, Plus-X film, and a 2½-hour exposure.

Last summer's eclipses spurred a mountain of astrophotos. Alex York of San Diego captured the June 30 solar eclipse from the window of a DC-10 41,000 feet above the ground. The resulting image (far right) nicely shows the Sun's delicate corona. Stationed in Mexico City, Alberto Levy used a multiple exposure to record the lunar eclipse on June 14/15 (right).

Other astrophotographers enjoyed capturing on film the delicate hues of the southern sky. Jim Barclay photographed star trails around the south celestial pole over his observatory near Bunya Mountains National Park, Australia (bottom). With a simple camera and tripod, Antonio Cesar Negreiros photographed Alpha and Beta Centauri and the Southern Cross from Campinas, Brazil (top).

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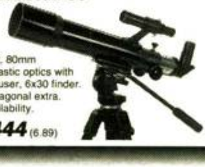

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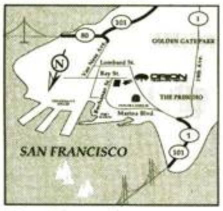

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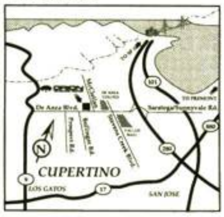

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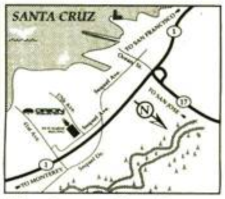

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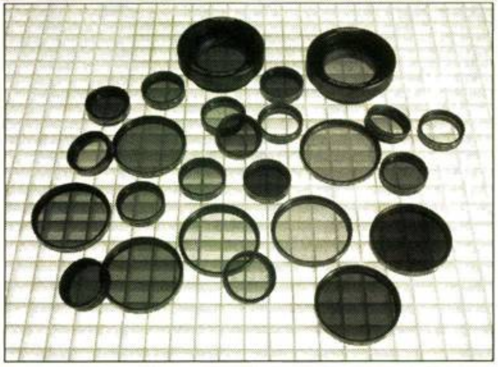

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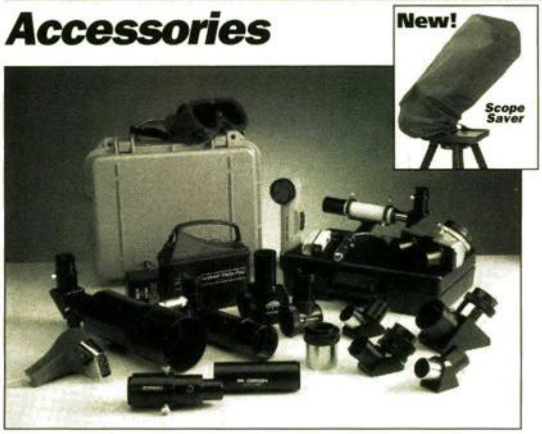

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Get the widest possible field of view from your Schmidt-Cassegrain Telescope. This star diagonal features a special aluminized and overcoated precision first-surface flat mirror.

#8767 **$89.95** (3.45)

Rack & Pinion Focusers

These top quality focusers are designed for Newtonian reflectors. Fit any size tubes.

1.25" Focuser #13017 **$42.95** (2.98)
2" & 1.25" Focuser #13019 **$79.95** (3.95)

Orion® UltraGuider™

Advanced features at a low price. Use with Meade or Celestron SC. Easily adjustable prism. Ultra-precise helical focus of your eyepiece, adjustable camera focal plane position.

#5139 **$109** (4.19)

Orion® Premium Off-Axis Guider

High performance, Multi-Coated, precision anodized. Low Orion price!

#5144 **$44.95** (3.45)

Basic Camera Adapters

Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring (sold separately).

.965" #5268 **$24.95** (2.98)
1.25" #5264 **$29.95** (2.98)

Vari-Power Camera Adapter

Unique sliding barrel design allows variable projection distances during eyepiece projection photography, eliminating the need to change eyepieces when magnification changes.

#5262 **$39.95** (2.98)

Orion® T-Adapter for SC

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 4", 8", 10", 11", 14" SC. Can be used as 2" camera adapter.

#5116 **$24.95** (2.98)

Orion® Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

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Variable Tele-Extender #5127 **$34.95** (2.98)

Orion® Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth.

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FlexiShield™ Dew Caps

Eliminate dew problems with FlexiShield! Better performance, more rugged, and easier storage than rigid dew caps. Forms into a tube with the velcro closure, opens flat for easy storage and transportation. Fits your telescope tube snugly, with wide rubber padding and full length velcro closure—needs no screws. Models to fit most telescopes.

8" Celestron/Meade Schmidt-Cassegrains
#4200 **$39.95** (2.98)
Plus nine other models for scopes 3.5" to 14"—Call toll-free!

Orion® Dew Zapper

Orion's Dew Zapper is a sure-fire cure for dew problems on your 8" or 10" Celestron or Meade Schmidt-Cassegrain telescope. Dew Zapper gently replaces lost heat, bringing the corrector plate temperature slightly above air temperature.

8" Dew Zappers —fit all Meade & Celestron 8" Schmidt-Cassegrains
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10" Dew Zappers—fit all Meade 10" Schmidt-Cassegrains
DC Model #3506
AC Model #3508
$49.95 (2.98)

Dew Remover Gun

Moisture that interferes with viewing dissipates quickly with this 12V DC, 156 watt warm air gun. Has 4-1/2' cord.

#5601 **$17.95** (2.78)

Metal-Reinforced Accessory Cases

Keep accessories and camera safe and clean. Diced-foam insert can be tailored to your needs. New black & chrome exterior with sturdy handle, two latches, key lock.

Regular Case: 16"x12"x6.5"
#5920 **$59.95** (7.10)

Large Case: 19.5"x12"x6.5"
#5921 **$69.96** (7.10)

Scope Saver Telescope Covers

Keep your Schmidt-Cassegrain covered and keep the dust and dew away! Fits the telescope either on the tripod or in the case. Blue waterproof nylon fabric. Drawstring closure with cord lock.

8" Model #15130 **$33.95** (2.43)
10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)
Ask about other sizes.

Deluxe Eyepiece Case

This durable case with double hinges holds up to 10 eyepieces plus barlow. Die cut foam insert for snug fit. O.D. 8-1/2"x12-1/2"x3-1/8".

#5913 **$17.95** (2.78)

Field Tripod Tote Bag

With padded insert to separate wedge from field tripod during transportation. For wedge combinations of Schmidt-Cassegrains up to 10" aperture. Allows storage without changing polar alignment. Tear and mildew resistant blue Cordura nylon.

#15096 **$79.95** (5.19)

Observer's Chairs

Make observing more comfortable and enjoyable with one of these great chairs.

Standard Model—Has adjustable height center column and padded vinyl seat. Folds for easy storage.
#5935 **$39.95** (4.70)

Deluxe Model—Is much heavier-duty, built for professional musicians. Extra thick padding, wide footprint. Adjustable and disassembles for storage.
#5934 **$89.95** (8.02)

12 Amp Hour Porta Pac Battery

Ideal for operating your telescope plus higher power-consuming accessories such as an Orion Dew Zapper. Battery is encased in high impact polystyrene. Carrying case of Cordura nylon with shoulder strap and handle. Wt. 10 lbs.

#2354 **$109 ea.** (8.97)

PRECISION SOLAR FILTERS

Thousand Oaks Optical solar filters are recognized around the world for their quality, consistent density and even coating across the entire aperture. We specialize in solar filters only and are the largest solar filter manufacturer in the world. Filters are available to fit all brands of telescopes and binoculars. **Thousands of our filters are in use around the world. The preferred choice of telescope dealers and exclusively used by NASA aboard the Space Shuttle.**

TYPE 1 - Made from high quality hand select glass, machine polished and **TRIPLE COATED** with a Nickel-Chromium alloy (same as Inconel). Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

TYPE 2 - Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

TYPE 3 - Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 and 2. Type 3 filters are for photographic use only.

Type 1 & 2 are for unlimited visual use and general photographic use. Instructions included with all filters, including tips on solar photography.

Our filters are many times more durable than common aluminized Mylar. Aluminized plastic cannot hold up to long term ultraviolet radiation and environmental contaminants as well as Nickel-chrome and stainless steel coated glass. Wrinkled Mylar can cause visual and photographic difficulties, can be easily damaged in handling or if placed on an uneven surface, and is difficult to clean. Also, a light blue solar image does not yield as much detail and contrast.

GLASS (Full Aperture) Type 1

Aperture	mounted:	Aperture	unmounted:
2.4"	$ 49.00	2.4"	$ 39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5" to 4"	49.00
4¼" to 5"	74.00	4¼" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00
40mm to 80mm Binoculars - Mounted			$ 92.00 pr.

GLASS (Full Aperture) Type 2

Aperture	mounted:	Aperture	unmounted:
2.4"	$ 62.00	2.4"	$ 52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5" to 4"	66.00
4¼" to 5"	96.00	4¼" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	119.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00
40mm to 80mm Binoculars - Mounted			$115.00 pr.

GLASS (Full Aperture) Type 3

Aperture	mounted:	Aperture	unmounted:
2.4"	$ 79.00	2.4"	$ 65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5" to 4"	79.00
4¼" to 5"	125.00	4¼" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

THREADED CAMERA FILTERS

All standard sizes available from 46mm to 82mm in Type 2 or Type 3. Please call or write for additional information.

ORDERING INFORMATION: Solar filters are shipped free in continental U.S. when payment is included with order. Shipping extra on credit card orders ($3 - $6 depending on aperture). Payment may be made by personal check, bank check or money order. We also accept **Visa, Mastercard** and **American Express. PLEASE SPECIFY TELESCOPE BRAND AND/OR OUTSIDE DIAMETER MEASUREMENT OF TELESCOPE TUBE.** The cost of the filter is based on the telescope aperture. The mounting cell fits over and around the end of the telescope tube (friction fit). The coating faces the inside. Unmounted filters are the glass only.

Free brochure available. Foreign inquiries: Please include $1 for return airmail postage of brochure. Proforma invoices available upon request.

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Plastic

Same as Mylar except this filter yields a sharper image with orange transmission.

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Minimum order of 10 eclipse filters in any combination. Please add appropriate shipping/handling. 10 units: $3.00. Plus $1.00 for each additional 10 units. Minimum credit card order of $25.00. Quantity discounts available starting at 100.

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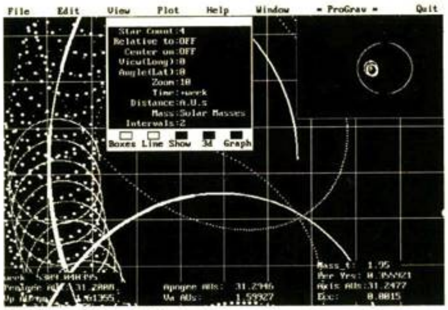
☐ Have an original, high quality program to publish? Please write for our Programmer's Guidelines.



```
Star Count:4
Relative to:OFF
Center on:OFF
View(Long):0
Angle(Lat):0
Zoom:10
Time:week
Distance:A.U.s
Mass:Solar Masses
Intervals:2
```

```
Perigee AUs: 31.2000
Apogee AUs:  31.2946
Va AUs:      1.59927
Mass_t:  1.95
Axis AUs:31.2477
Ecc:     0.0015
```

☐ **Gravitator Pro™** - Adds these features beyond Plus: 2nd view window allows seeing system from another scale or orientation. Binary orbital pairs can be added by inputing orbital elements. Orbit objects can be added to existing bodies. Optional 3D plotting uses red/green images & supplied 3D glasses for depth effects. Plot radial velocities of any two bodies. Track orbit function follows 2 bodies & shows closest approach, distance& velocity, perihelion, eccentricity & more. Save and recall screen images as PCX graphic files, use in other programs. Prints portrait or landscape, scale laser images. IBM EGA/VGA. Dot matrix or laser printers. **$149.95**

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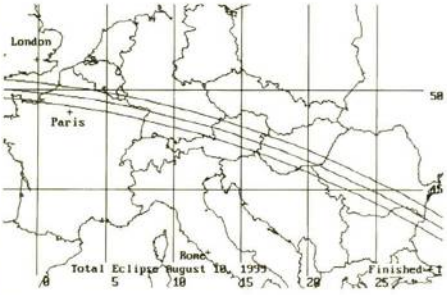

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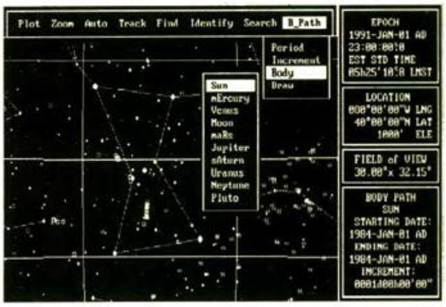

```
EPOCH
1991-JAN-01 AD
23:00:00:0
EST STD TIME
05h25'10"0 LMST

LOCATION
000°00'00"W LNG
40°00'00"N LAT
1000' ELE

FIELD of VIEW
30.00°x 32.15°

BODY PATH
SUN
STARTING DATE:
1984-JAN-01 AD
ENDING DATE:
1984-JAN-01 AD
INCREMENT:
0001d00h00'00"
```

```
Partial Solar Eclipse
Magnitude: 0.170  Obscuration:  0.3%
LAST CONTACT
```

```
<***   NGC 3034  Located at TARGET   ***>
NGC# ObjTyp Cst  Mag Type        Size   R
3034 Galaxy UMA  9.5 Am         11'x 5'
(CIRCUMPOLAR)   TT: 17h35'20"3   (CIRCUMPOLAR)
```

☐ **LodeStar Plus™** All features of 2.1 version and these additions: High resolution 16 colors with EGA/VGA modes. Includes all 7840 NGC galaxies, clusters, nebulae, etc. Options to plot RA&Dec grids and constellation boundaries. Automatically search for and see solar and lunar eclipses, planetary conjunctions, occultations. Plot the paths of Sun, Moon & planets on sky view. Video mode lets you record screens to display later for reference or demonstrations. Calculates parallax, nutation and aberration and ephemeris time corrections for high accuracy. Supports any of 300 printers, dot, laser or jet. Sophisticated interface including pull-down menus and mouse support to easily access all 78 functions. IBM & compat. Hercules, CGA/EGA/VGA. Works with or w/o co-processor. **$149.95**

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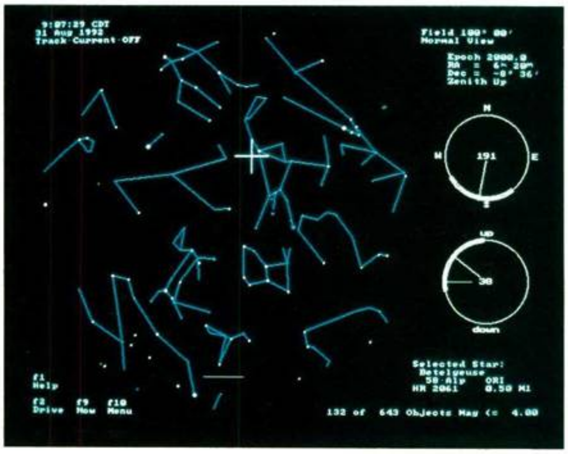

ASTRONOMY: Darla Gawelski

***Expert Astronomer I (version 1.0.86)**, Expert Software, P.O. Box 144506, Coral Gables, FL 33114-9851. Phone (800) 759-2562. $14.95. Minimum requirements: IBM PC-compatible computer, DOS 3.0, 512 KB of RAM memory, CGA display, and hard disk with 600 KB of free space or high-density floppy drive. Math coprocessor and mouse are recommended. Both 5¹/₄" and 3¹/₂" diskettes are included. A Macintosh version, not reviewed here, is available for $49.95.*

If you're looking for an inexpensive program that will plot sky maps and the positions of the planets, look no further. Expert Astronomer is widely available for about $10 in computer, department, and office supply stores. It's not highly polished, but it's a solid program that will satisfy the needs of most first-time users of planetarium programs. And parents will like the price — it's inexpensive enough to let a child try out his or her interest in astronomy.

Expert Astronomer has the standard capabilities of a planetarium program: you can plot the positions of all the bright stars, draw constellation figures, and plot the positions of the planets and deep-sky objects. You can change the field of view from 4 to 180 degrees. Simple altitude and azimuth circles indicate where in the sky you are looking. You can choose your observing site from 458 cities worldwide — Aberdeen, Scotland, through Zurich, Switzerland — or enter the latitude and longitude.

The database includes 9,221 objects, including almost 9,100 bright stars and the Messier objects. You can search for these objects by star name, Bright Star Catalog number, Messier object number, or NGC number. Each object is automatically identified as the cursor is moved over its position.

Additional features include animation of celestial events and the ability to plot stars by their color, or to print their magnitudes or spectral types on the display. Eleven animations are preprogrammed, including the solar eclipse of July 1991, the December 1992 lunar eclipse, and the retrograde motion of Mars. As Mars passes a star, the program prints out its identity. For astrophotography, you can superpose a frame showing the coverage of lenses from 20 mm to 1,000 mm in focal length. You can plot grid lines, but they can be somewhat crude for wide fields. Remember, however, the program's low price.

Like most programs, Expert Astronomer has a few bugs. The planets disappear from the display when stars are plotted in color instead of in white. No error message is printed when you input incorrect values. The calculated planetary positions are sufficiently accurate for most uses — better than 3 minutes in right ascension and 4 arcminutes in declination — but the magnitudes are generally 1 magnitude too faint for the dates tested. I would also prefer that the menu stay active unless I specifically want to turn it off. The horizon view should show the entire horizon, not just a short line.

Expert Astronomer is clearly a bargain. It has many features found in higher-priced planetarium programs and some features, such as the camera frames, that aren't. It can be slow at times and the user interface isn't highly polished. But it is an excellent entry-level program, especially for beginners making their way into computer astronomy. Teachers will find it a great low-cost addition to their classroom, and parents will find it a great lost-cost way to stimulate an interest in astronomy in their children. If you don't have a planetarium-type program for your computer, this is an excellent place to start. — *Dave Bruning*

NEW SOFTWARE

***Planetary Event and Eclipse Predictor (PEEP)**, CEB Metasystems Inc., 1200 Lawrence Drive, Suite 175, Newbury Park, CA 91320. Phone (805) 499-0958. $39.95. Minimum requirements: IBM PC-compatible computer, 640 KB memory, 738 KB of available hard disk space, DOS 3.3, and an EGA display. A mouse and math coprocessor are recommended.*

PEEP calculates the times and locations of planetary conjunctions, stellar occultations, and solar and lunar eclipses using the methods published by Jean Meeus in *Astronomical Algorithms*. A graphical user interface eases use of PEEP. The program also can generate a data file for use with CEB Metasystems' Stargaze software.

***Murmurs of Earth**, Warner New Media, 3500 Olive Avenue, Burbank, CA 91505. Phone (818) 955-9999. $59.95. Minimum requirements to view images: IBM PC-AT compatible computer, 640 KB memory, Super-VGA display, and a CD-ROM drive; or a Macintosh LC- or II-series computer, system 6.0.5, 2 MB of available memory, and a CD-ROM drive. Includes the 277-page book* Murmurs of Earth*, originally published by Random House and reissued for this set.*

Each Voyager spacecraft carries a gold-plated record that contains information about planet Earth, including 115 images, messages in 54 languages, and 90 minutes of music. Although the original record was designed for play at $16\frac{2}{3}$ rpm — the considerate spacecraft designers included a needle for whoever discovers the record — you can view the images and listen to the music using Warner New Media's multimedia set. The first track of the CD-ROM set contains 114 of the record's 115 images. The remaining tracks contain the greetings and music. You must use a computer CD-ROM drive to view the images, but you can listen to the music with any CD player. The book *Murmurs of Earth* contains information about the record and a collection of photos taken by Voyagers 1 and 2.

Correction

The October AstroBytes incorrectly listed the street number for CompuScope, makers of Imagine-32 software. The correct address is CompuScope, 3463 State Street, Suite 431, Santa Barbara, CA 93105. Phone (805) 687-1914. ☐

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- ★ If the Official Entry Form is missing from this magazine, send a postcard with your name, address, home phone number and this magazine's issue date to: ASTRONOMY Sweepstakes, P.O. Box 1612, Waukesha, WI 53187-1612. Cards must be postmarked by the last day of the month of the cover date of this issue. Entries are limited to one per person per month.

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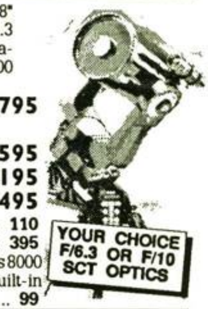
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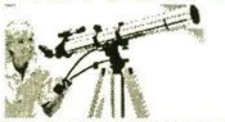

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EXCEPTIONAL AND UNCOMMON TELESCOPES

Unusual Telescopes, by Peter L. Manly, (Cambridge University Press, 1991), ISBN 0-521-38200-9, 221 pages, hardcover, $39.95.

Manly describes numerous telescopes of unusual optical or mechanical design, including some downright whimsical telescopes such as his fork-mounted telescope that perches on a dining implement. Most of the telescopes are serious backyard or professional instruments — present-day and historical — that have some unique design feature. And some non-telescopic instruments are included, such as barn-door-type camera platforms and all-sky cameras. This book will appeal certainly to telescope makers, but also to other readers who want to learn about extraordinary telescopes or about developments in mirror and telescope technology.

Optical designs Manly considers include flexible mirrors, plastic optics, and ceramic and metal mirrors. Telescope mounts range in design from no axes of motion to four or more axes, and from simple wood mounts to truck- and trailer-mounted telescopes. Manly describes several designs in which either the observer moves with the eyepiece or the eyepiece is stationary.

One chapter describes the limits of telescopes: how big a refractor can be, how long a refractor can be, how small a telescope can be (0.2 millimeter), and how single mirrors can combine images to create effectively larger telescopes.

Manly has written a fascinating book that records astronomers' efforts to observe the sky with uniquely crafted instruments. The book contains many photos and illustrations to help you see how these telescopes work. Manly also includes references if you wish to learn more about a particular design. Every reader of this book will find at least one design that will either amaze, amuse, or fascinate. I'm still chuckling about the fork-mount. — *Dave Bruning*

Space

At the Edge of Space: The X-15 Flight Program, by Milton O. Thompson, (Smithsonian Institution Press, 1992), ISBN 1-56098-107-5, 375 pages, acid-free paper, hardcover, $29.95.

The X-15 was a rocket-powered aircraft that bridged the gap between airplanes and spacecraft. During the 199 flights of the X-15 from June 1959 to October 1968, the aircraft rose to altitudes as high as 354,200 feet (67 miles) and achieved speeds up to 4,520 miles per hour (6.7 times the speed of sound). The aircraft tested many different types of materials for use in the Apollo, space shuttle, and other space programs. Two of the pilots —Neil Armstrong and Joe Engle — later became astronauts.

Thompson describes the pilots and the aircraft from his intimate knowledge as an engineer and research pilot in the program. He relates the story of the X-15 as a series of personal anecdotes instead of dry technical information. Transcripts of the pilots' conversations with ground controllers and chase-plane pilots detail some of the aspects of typical — and some not so typical — X-15 flights. Appendices include logs for all 199 flights and flight statistics for each of the pilots.

Solar System

The Wrong-Way Comet and Other Mysteries of the Solar System, by Barry Evans, (TAB Books, 1992), ISBN 0-8306-2670-0, 171 pages, softcover, $14.95.

Sixty short essays describe the Sun, Earth, planets, comets, asteroids, and meteorites. Based loosely on newspaper columns written by Evans over the last five years, the essays are easy-to-read and contain simple, brief definitions or explanations of important physical ideas. The friendly approach makes up for some of the book's minor errors.

Mars, by Ben Bova, (Bantam Books, 1992), ISBN 0-553-07892-5, 502 pages, hardcover, $20 ($24 in Canada).

Bova's science fiction novel about a future manned mission to Mars warrants attention. The fast-paced story is not full of fanciful ideas about the Red Planet; instead it echoes many of the ideas presently being considered for actual missions to Mars. The detailed description of the Martian atmosphere and surface features is quite good and makes the fictional parts of the story seem believable. Predictably Bova's astronauts and international team of scientists who travel to Mars' surface encounter a life-threatening crisis, but its resolution is a pleasant surprise. If you like good science fiction or want to learn what future missions to Mars might entail, read this book. — *Dave Bruning*

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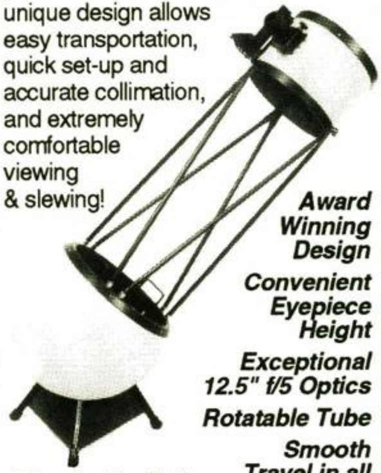

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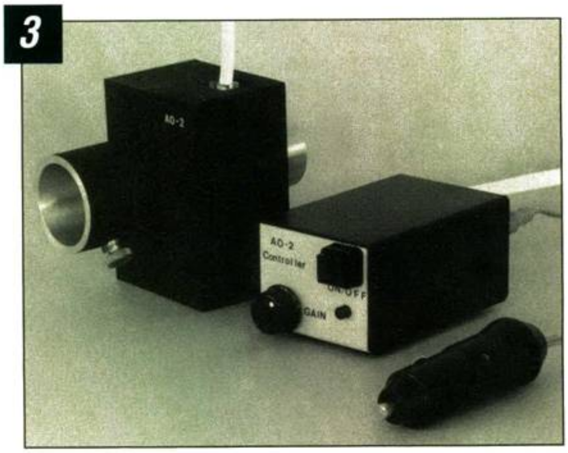

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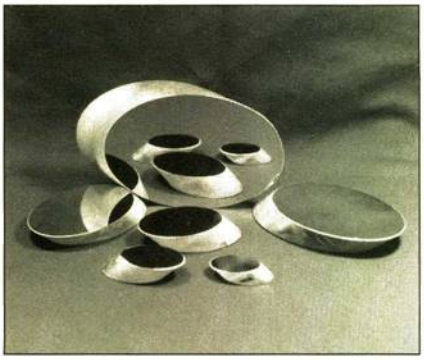

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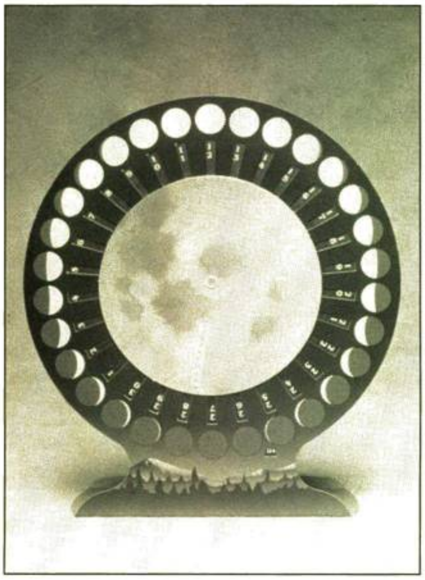

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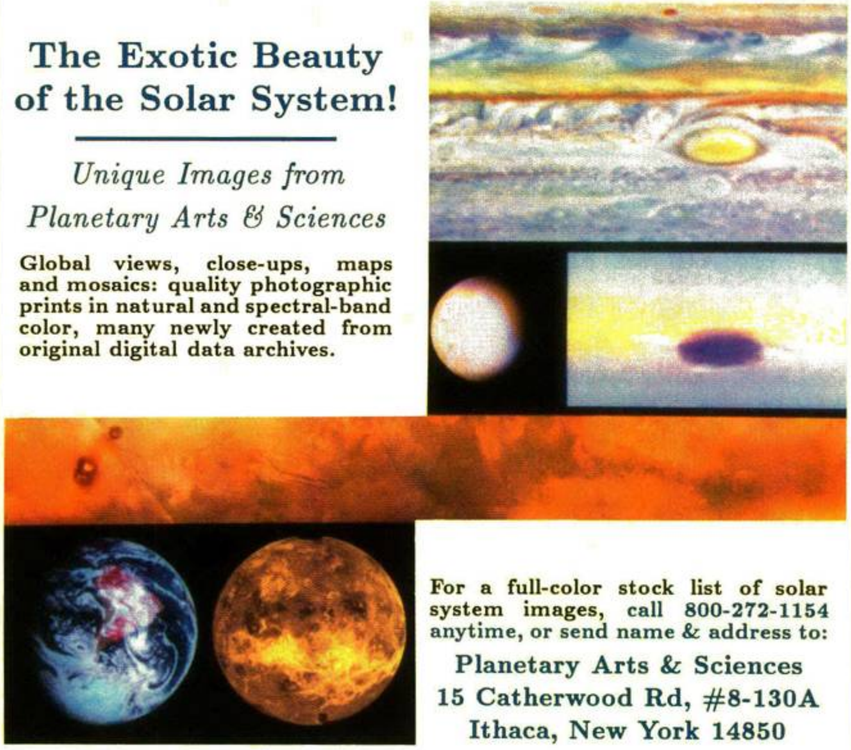

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[Images shown — upper right: Jupiter map projection in Great Red Spot vicinity, enhanced color; Neptune Great Dark Spot vicinity; Triton, enhanced UV-shifted color (all Voyager 2) — middle: strip of Mars color map (Viking) — bottom left: Earth near-infrared color over (72°E, 34°S) (Galileo); Venus global projection of Magellan radar mosaic, over (110°E, 5°N).]

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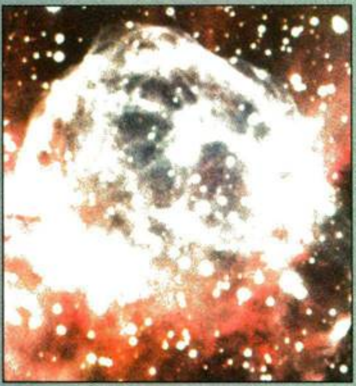
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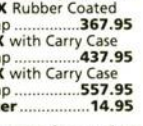

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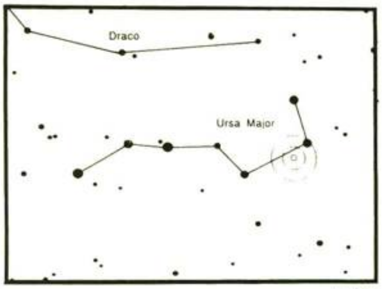

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Meetings & Events

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Lake Kissimmee Star Party, Lake Kissimmee State Park, Lake Wales, Florida. Contact: George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853. Phone: (813) 696-1112 (before 2 p.m.), (813) 696-1812 (after 5 p.m.)

December 1-2
Asteroid Safety Conference, Albuquerque, New Mexico. Contact: Safety Research Institute, P. O. Box 9123, Albuquerque, NM 87119-9123. Phone: (505) 255-9801.

December 19
2nd Annual ASV Christmas Star-Be-Que, near Heathcote, Australia. Sponsored by the Astronomical Society of Victoria. Contact: Perry Vlahos, 103A Orrong Cresc., North Caulfield, Victoria 3161 Australia. Phone: (03) 527-8719.

April 5-7, 1993
Second Solar Astronomy Convention, La Paz, Baja California Sur, Mexico. Sponsored by the La Paz Station of the Solar Astronomy Research Center. Contact: Calle La Purisima 119, Colonia Bellavista, Codigo Postal 23050, La Paz, Baja California Sur, Mexico. Phone: 91-682-1-07-32. ☐

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WANTED — New amateur astronomer seeks correspondence regarding astronomy, planetary sciences, etc., with astronomers worldwide. Contact Pat Milburn, 4125 Center St. N.E., Apt. 82, Salem, OR 97301.

WANTED — Twenty-four-year-old woman interested in astronomy and other sciences wishes to correspond with others worldwide. Contact Iris Didschuns, Strausberger Strasse 41, O-1017 Berlin, GERMANY.

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ANNOUNCEMENT — Going to Denmark? Køge Bugt Astronomy Club invites you to their meetings. Will suggest interesting astronomy places in Denmark. Contact Camilla Bacher, Tavleager 37, 2670 Greve, DENMARK.

WANTED — Correspondence with other astronomy clubs, exchange ideas, etc. Contact Camilla Bacher, Tavleager 37, 2670 Greve, DENMARK.

ANNOUNCEMENT — Voice your opinion to those who make improperly shielded security lights that ruin dark-sky observing. For a list of companies, contact Alan Raycraft, Box 836, Woodland Park, CO 80866.

WANTED — Twenty-eight-year-old would like to correspond with people interested in asteroid and planetary orbits, exotic conjecture/fact, and a balance of homespun wit. Contact Tim Holmes, San Chuan Rd., 98 Alley 29 Lane, 13-1 5 Floor, Fengyuan Taiwan, REPUBLIC OF CHINA.

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Readings & Credits

Building the Glass Giant of Palomar (page 30)

The Glass Giant of Palomar, by David O. Woodbury, (Dodd, Mead, and Company, 1940). A contemporary account of the 200-inch telescope construction.

Palomar Pictorial, (published Caltech and Carnegie Institution of Washington, 1965). Contains photo of the 200-inch scope under construction and in use.

Giving Birth to Supernovae (page 46)

"Insight Into Star Death," by Richard Talcott, ASTRONOMY, February 1988. Describes observations of Supernova 1987A and why Sanduleak –69°202 exploded.

"Galactic Archaeology," by Ken Croswell, ASTRONOMY, July 1992. Describes how different types of supernovae enrich the chemical composition of our Galaxy.

Supernovae, by Paul and Leslie Murdin, (Cambridge University Press, 1985). A good standard introduction to the physics of supernovae.

Taking Pictures with Telescopes (page 66)

Astrophotography for the Amateur, by Michael Covington, (Cambridge University Press, 1991). A recently revised introduction to all the basic techniques.

The Backyard Astronomer's Guide, by Terence Dickinson and Alan Dyer, (Camden House, 1991). Contains extensive chapters on astrophotography.

"Telescopes for Astrophotography," by Alan Dyer, ASTRONOMY, November 1990. What to look for when purchasing a telescope for astrophotography.

Exploring the Winter Sky (page 80)

Stars and Planets, by Donald H. Menzel and Jay M. Pasachoff, (Houghton-Mifflin, 1990). A handy pocket-sized guide containing star maps and descriptions of what you can see in each constellation.

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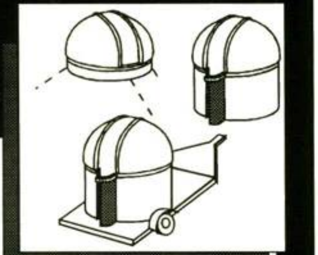

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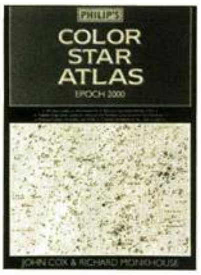

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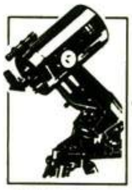

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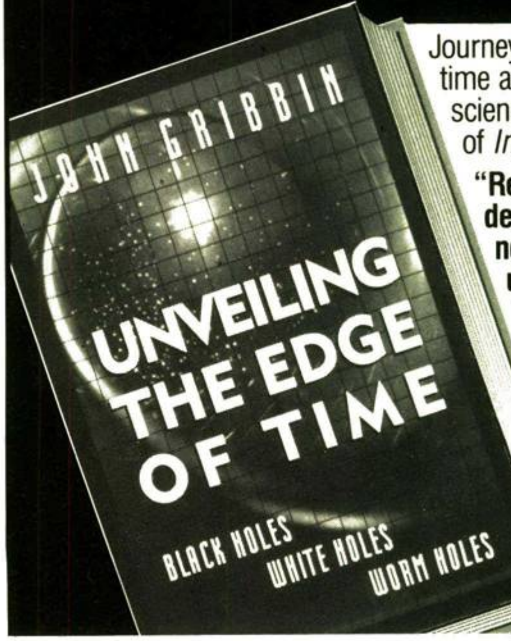

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